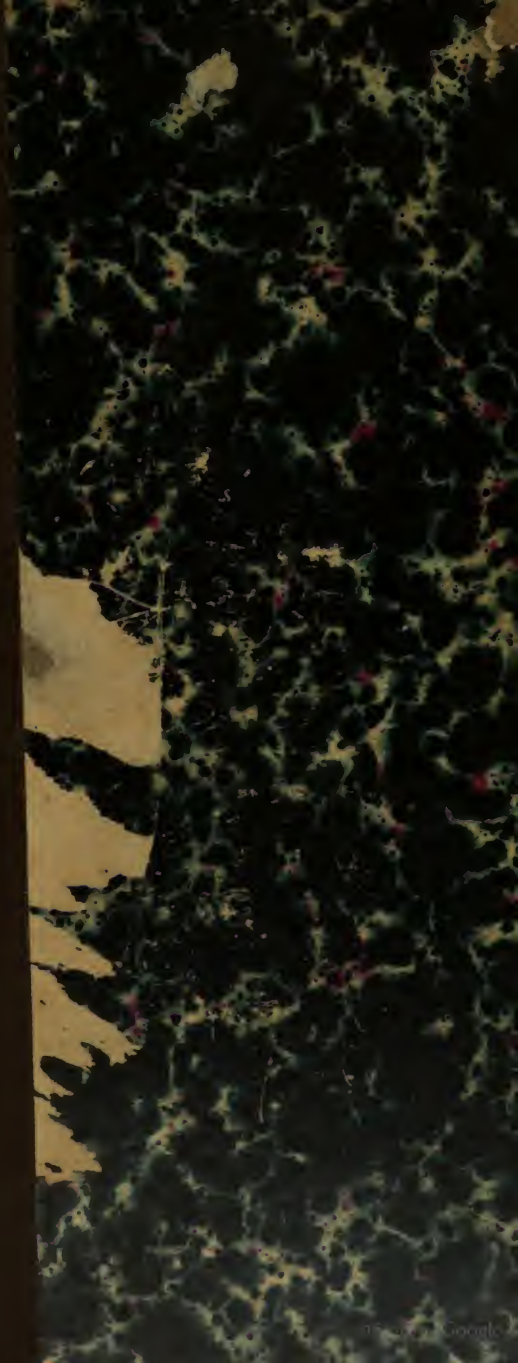


WIDENER



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ON THE
FLUORINE COMPOUNDS
OF
URANIUM.

INAUGURAL DISSERTATION
FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
ADDRESSED TO
THE PHILOSOPHICAL FACULTY
OF THE
UNIVERSITY OF GOETTINGEN

BY
H. CARRINGTON BOLTON
OF NEW YORK.

BERLIN.

PRINTED BY UNGER BROTHERS, PRINTERS TO HIS MAJESTY.

1866.

P R E F A C E.

The following researches were begun in the Laboratory of the University of Göttingen at the suggestion and under the direction of Professor Wöhler, to whom I here express my heartfelt thanks for the great kindness and unremitting attention conferred upon me during my residence in Göttingen. The investigations were completed in the University Laboratory at Berlin under Professor Hofmann, to whom I also acknowledge my indebtedness.

My sincere thanks are due to Drs. R. Fittig and C. A. Martius the gentlemenly and able assistants in the respective Laboratories, for their kind assistance in this work.

Berlin. January 28th 1866.

NOTE.

Within a very few years the attention of chemists has been directed to the *quantivalence* (or atomicity) of the elements, which has given rise to new theoretical speculations respecting the constitution of chemical bodies. So new are these theories however, that not a few elements remain to which they are still to be applied. Thus it happens that no chemist who has studied *uranium* and its compounds, and none of the literature whether in textbooks, monographs or dictionaries, treats this subject in the light of these modern theories.

In this dissertation therefore the formulae being new, and these necessitating the employment of new names, I have added the old names throughout and occasionally the old formulae; giving to the latter however a subordinate place corresponding to their importance. .

Our present knowledge of the uranium compounds is too limited to allow us to establish with any degree of certainty the *quantivalence* of this metal; but the facts warrant the doubling of the old atomic weight as given by Péligré, and it is taken in the following pages as equal to $(2 \times 60 =) 120$. Should a compound of uranium be hereafter discovered which is sufficiently volatile to admit of determining its vapor-density, and this is by no means improbable, then the true *quantivalence* of the element can be firmly established.

INTRODUCTION.

In the year 1789, Klaproth¹ discovered in pitchblende a peculiar metallic oxide to which he gave the name uranium. Richter,² Bucholz,³ Lecanu⁴ and Brande⁵ were among the first to examine this element more closely. In 1823 the literature on uranium was greatly enriched by the labors of Berzelius⁶ and Arfvedson,⁷ the latter estimating its equivalent which he found equal to 2711 (O = 100). The non-metallic nature of this metal (if the expression may be allowed), its high atomic weight and other discrepancies gave rise to doubts, but it was not until 1840 when Péligré⁸ made known his remarkable discovery that the doubts were confirmed and the discrepancies explained. Péligré found that the substance till then considered as metallic uranium was in reality an oxide of the true metal and he showed how the latter might be obtained.

Since this date uranium has been a more frequent sub-

¹ Beiträge zur chemischen Kenntniss der Mineral-Körper, Vol. II, p. 197.

² Neue Gegenstände der Chemie, Vol. I, p. 1. Vol. IX, p. 36.

³ Gehlen, neues allgemeines Journ. d. Chem., Vol. IV, pp. 17 et 134.

⁴ Schweigger's Journ. f. Chem. u. Phys., Vol. XLIV, p. 35.

⁵ Schweigger's Journ. f. Chem. u. Phys., Vol. XLIV, p. 1.

⁶ Poggend. Annal., Vol. I, p. 359.

⁷ Poggend. Annal., Vol. I, p. 245.

⁸ Annal. de chim. et de phys., III, Vol. V, p. 5.

ject of research. Rammelsberg,¹ Ebelmen,² Wertheim,³ Kühn,⁴ Patera,⁵ Drenkmann⁶ and others have published their investigations, more or less extensive, on this subject.

It is not my object in this dissertation to give a more complete history of the element uranium, much less to enumerate its various salts, but I will briefly notice its most important compounds with the halogens which stand in close analogy to the fluorine compounds herein discussed. Before entering upon a description of these salts, it will not be out of place to detail the method employed for procuring the nitrate of uranium which forms the starting point in their preparation.

¹ Poggend. Annal., Vols LV, LVI et LIX.

² Annal. d. Chem. u. Pharm., Vol. XLIII, p. 286.

³ Journ. f. prakt. Chemie, Vol. XXIX, p. 209.

⁴ Annal. d. Chem. u. Pharm., Vol. XLI, p. 337.

⁵ Journ. f. prakt. Chemie, Vol. LXI, p. 397; Chem. Centralbl. 1856 etc.

⁶ Zeitschr. f. d. gesammten Naturw., Vol. XVII, p. 113. Jahresber. 1861, p. 255.

EXTRACTION OF URANIUM FROM PITCHBLENDE.

The only mineral which occurs in sufficient abundance to be employed as a source of uranium is the well known pitchblende (uranpecherz). I received through the kindness of Prof. Wöhler a quantity of pitchblende from Joachimsthal in Bohemia. It was of a brownish black color with a dull metallic lustre and remarkably free from gangue. The finely pulverized mineral was digested in a porcelain vessel with concentrated sulphuric and nitric acids until the greater portion was dissolved; the excess of sulphuric acid was then expelled by heat.

The mass was treated with water and the filtrate from the white residue was heated and saturated with sulphuretted hydrogen. After standing twenty four hours it was filtered, the iron and uranium in solution were oxidized with chlorate of potassium and hydrochloric acid while boiling, and then thrown down by an excess of ammonia. This mixed precipitate was well washed and digested with a strong hot solution of carbonate of ammonium until the precipitate assumed the appearance of oxide of iron. The hot solution of uranium was then quickly filtered and yellow crystals of the double salt carbonate of uranium and ammonium $(UO)_2 CO_3 + 2 (NH_4)_2 CO_3$ deposited on cooling. The mother liquid united to the wash-water (which was collected separately) yielded by boiling a precipitate of

hydrated oxide of uranium, $U_2O_3 \cdot H_2O$. By calcining these two salts and dissolving the green oxide formed in nitric acid, large crystals of nitrate of uranium $(UO)NO_3$ were obtained which were purified by recrystallization.*

Advantage was taken of the comparatively large scale of operations to submit the several residues to a careful qualitative analysis and with the following results. The first white insoluble portion was found to consist chiefly of sulphate of lead, with small quantities of bismuth and lime. The precipitate by sulphuretted hydrogen contained arsenic, copper, bismuth, a trace of selenium and a not inconsiderable quantity of silver. Whether the latter formed a constituent of the pitchblende, or whether its presence should be attributed to the fact that the mineral came from the neighborhood of silver mines, I could not determine. The filtrate from the mixed precipitate of iron and uranium contained manganese and magnesia. On treating the green oxide with nitric acid, it was not completely dissolved. The yellowish residue was melted with carbonate of sodium, dissolved in hot water, and after filtering from the uranate of sodium which formed, the solution gave with chloride of ammonium the reaction characteristic of vanadium.

To recapitulate: the pitchblende from Joachimsthal contained arsenic, selenium, lead, copper, bismuth, silver, uranium, iron, manganese, a trace of vanadium, magnesia-lime and silicic acid.

* Wöhler's „Mineral Analyse in Beispielen“ p. 156 et seq.

I. URANIUM AND CHLORINE.

BICHLORIDE OF URANIUM, UCl_2 , (protochloride of uranium, UCl) discovered by Pélégot forms the material for the preparation of the metal. It is prepared by heating a mixture of the protoxide or of the green oxide with charcoal in a tube through which a current of dry chlorine is passing. It is a dark green volatile body crystallizing in octahedra and exceedingly deliquescent in a moist atmosphere. Its solution is decomposed by evaporation with disengagement of hydrochloric acid. When heated with sodium or potassium it yields metallic uranium in small globules; but notwithstanding the violence of the reaction the heat developed is not sufficient to fuse the metal, and it can be obtained only in very small quantities.

A SUBCHLORIDE has been obtained by heating the bichloride in a current of hydrogen, which according to Ramelsberg has the formula U_2Cl , UCl but according to Pélégot U_2Cl , 2UCl . It dissolves in water with a purple color, but quickly decomposes with disengagement of hydrogen and precipitation of a reddish powder, the hydrate of the protoxide; the solution at the same time turning green.

OXICHLORIDE OF URANIUM, $(\text{U}\Theta)\text{Cl}$, (old notation $2\text{U}_2\text{O}_3$, U_2Cl_3) may be obtained by heating the protoxide, $\text{U}\Theta$, in a current of dry chlorine; as thus prepared it is a crystalline, fusible, slightly volatile body, soluble in water, alcohol and ether. Crystals of the same may be procured by evaporating the yellow solution obtained by dissolving the sesquioxide of uranium $\text{U}_2\Theta_3$ in hydrochloric acid. When heated with potassium this salt yields chloride of

potassium and protoxide of uranium. This compound forms a series of double salts with the chlorides of the alkaline metals, as follows:

OXICHLORIDE OF URANIUM AND CHLORIDE OF POTASSIUM, $(U\Theta)Cl + KCl + H_2\Theta$ (old notation, $U_2O_2Cl, KCl + 2aq.$)

This salt is prepared by dissolving uranate of potassium in hydrochloric acid and crystallizing the solution over sulphuric acid. The beautiful large greenish yellow rhombic plates form best in an acid solution and do not admit of recrystallization. When heated in a closed tube, it melts, parts with its water of crystallization and undergoes partial decomposition. If heated in a current of hydrogen it is decomposed with evolution of hydrochloric acid and leaves a greenish opaque residue.

OXICHLORIDE OF URANIUM AND CHLORIDE OF SODIUM, as well as the corresponding salt of AMMONIUM, have been prepared, but crystallize with great difficulty being deliquescent.

II. URANIUM AND BROMINE.

BIBROMIDE OF URANIUM, UBr_2 (Protobromide of uranium UBr) was first prepared by Hermann.* It is obtained by heating protoxide of uranium in a current of dry bromine gas, and constitutes a brownish crystalline mass which emits fumes in the air and deliquesces.

HYDRATED BIBROMIDE OF URANIUM, $UBr_2 + 4H_2\Theta$ (Hydrated protobromide of uranium, $UBr + 4HO$). Rammelsberg obtained this salt by dissolving the hydrate of the

* Inaug. Dissertat. Göttingen 1861.

protoxide in hydrobromic acid and evaporating the green solution in a desiccator.

OXIBROMIDE OF URANIUM, $(UO)Br$ (old notation, $2U_2O_3 \cdot U_2Br_3$) has been prepared by dissolving the hydrated sesquioxide in hydrobromic acid. It crystallizes in yellow deliquescent needles. Whether crystallized double salts can be obtained with the bromides of the alkaline metals has not been examined.

III. URANIUM AND IODINE.

The only compound of uranium and iodine as yet prepared is a BI-IODIDE UI_2 (protoiodide UI), containing water and obtained by Rammelsberg in treating the hydrated protoxide with hydriodic acid. Its properties have not been completely described.

IV. URANIUM AND CYANOGEN.

No compound of uranium and cyanogen has been yet procured.

V. URANIUM AND FLUORINE.

(HISTORICAL.)

The fluorine compounds of uranium have been very little studied. The first notice of a compound of uranium and fluorine is made by Berzelius in his "Researches on Hydrofluoric Acid and its most remarkable Compounds" which appeared in the first volume of Poggendorf's *Annalen* in 1824.* He briefly describes the oxifluoride of

* The original reads: "Untersuchungen über die Flussspathsäure und deren merkwürdigsten Verbindungen".

uranium as soluble in water and forming a yellow uncrystallizable solution. Later (1845) in his "Lehrbuch der Chemie" he repeats the facts before stated, gives the formula $U_2Fl_3 + 2U_2O_3$ and adds that the solution yields with the fluorides of the alkaline metals yellow crystallizable double salts. Berzelius also describes the silicofluoride of uranium as a bluish green precipitate and mentions further that the "protofluoride" (bifluoride) is unknown.

No chemist appears to have more closely examined these compounds until 1861 when Hans Hermann published his dissertation "On some Compounds of Uranium", in which he examined the action of hydrofluoric acid on the protos sesquioxide of uranium and describes the "protofluoride" (bifluoride) as a "sesquifluoride" having the formula U_2Fl_3 .

He gives the method of preparation and of analysis (though unfortunately no figures) and adds that this "sesquifluoride" contains water which is only expelled by a temperature of $200^\circ C$. I trust however it will be satisfactorily demonstrated in the following pages that the substance in question is an anhydrous bifluoride.

BIFLUORIDE OF URANIUM. UFl_2

(PROTOFLUORIDE OF URANIUM. UFl .)

PREPARATION I. Hydrofluoric acid in solution acts upon the green oxide of uranium with considerable vigor, causing an appreciable elevation of temperature; a yellow solution is formed together with an insoluble green powder which latter is the object of our immediate attention. If the acid employed be somewhat concentrated, the yellow solution is sirupy and admits of filtration, but it is nearly impossible to wash the precipitate upon the filter for it possesses the property of passing through the pores of the paper even if double or fourfold filters are employed. Long continued boiling of the solution with the precipitate does not prevent its persistently running through the filter. By operating upon comparatively large quantities, sufficient of the bifluoride was collected for examination and analysis; but it was far from being pure, and hence the figures given in the analyses of the salt as thus prepared are inaccurate.

PROPERTIES. The bluish green powder is insoluble in water and scarcely attacked by dilute acids; even concentrated nitric acid dissolves it but slowly. When boiled with a solution of caustic soda, it is decomposed and insoluble black protoxide of uranium is formed which is dehydrated by continued heating. The solution contains fluoride of sodium. If heated strongly on platinum foil it is decomposed with loss of fluorine and formation of the green oxide, without melting. When heated in a closed tube

it is found to contain no water. The green powder being in an exceedingly fine state of division is hygroscopic.

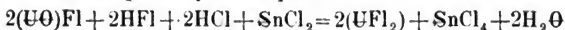
ANALYSIS. The salt having been dried at 100° C. a weighed quantity was dissolved by the aid of heat in concentrated nitric acid. The solution was diluted, the uranium precipitated with a slight excess of ammonia and this precipitate was washed partly by decantation partly on the filter with a dilute solution of chloride of ammonium. The uranate of ammonium was dried and ignited (with the filter) in a platinum crucible and weighed as $\text{UO}_2\text{U}_2\text{O}_3$.

I.	0.8553	gram.	substance	gave	0.7368	gram.	U_3O_4	=	73.1 %	U
II.	1.1845	"	"	"	1.0310	"	"	=	73.8 "	U
III.	0.8270	"	"	"	0.7197	"	"	=	73.8 "	U
	0.8270	"	"	"	0.3820	"	CaFl_2	=	22.5 "	Fl
	The formula		U_2Fl_6	requires		67.7 % U				
	"	"	$(\text{UO})\text{Fl}_2$	"	"	68.9 " "				
	"	"	$\text{UFl}_2 + \text{H}_2\text{O}$	"	"	68.1 " "				
but	"	"	UFl_2	"	"	75.9 " " and				
						24.1 " Fl.				

Therefore although the figures are far from satisfactory a glance shows the formula UFl_2 to be without doubt the true one.

PREPARATION II. Bifluoride of uranium may be obtained in a state of purity by reducing the oxifluoride of uranium by means of bichloride of tin. For this purpose the yellow solution resulting from the action of hydrofluoric acid on the green oxide of uranium, is heated in a platinum vessel with bichloride of tin as long as the green bifluoride falls. If hydrofluoric acid is added from time to time during the reduction, the whole of the uranium is precipitated and the filtrate is colorless, containing only the per-salt of tin.

Instead of the solution of the oxifluoride obtained as above mentioned, a solution of uranate of ammonium (or even of the double salt of carbonate of uranium and ammonium) in hydrofluoric acid may be employed with equal advantage. The following equation shows the reaction which most probably takes place:



As thus prepared the precipitate may be washed upon a filter without the least difficulty, and its behavior with reagents proves its identity with the salt obtained by the preceding method.

ANALYSIS. The uranium was estimated in this salt precisely as in the previous analysis. The fluorine was determined in a separate portion as follows: a weighed quantity of the salt dried at 100°C . was boiled with a strong solution of caustic potassa until the green color entirely disappeared, and the black protoxide of uranium was collected on a filter and washed with boiling water. This precipitate was weighed but found to contain potassa.

The filtrate was *nearly* neutralized with acetic acid and the fluorine thrown down by chloride of calcium. Carbonate of potassium in excess being present (the potassa having absorbed carbonic acid from the air, its addition is superfluous) carbonate of calcium falls with the fluoride of calcium, which is absolutely necessary to prevent the latter passing through the filter. The mixed precipitate was dried and ignited with the filter. The carbonate of calcium was dissolved out with acetic acid, the excess of acid driven off by evaporating nearly to dryness on a water-bath, and the fluoride of calcium was then brought upon a filter and washed until the filtrate no longer gave a

precipitate with oxalic acid. The precipitate was again ignited and weighed. The following are the results obtained.

- I. 0.7920 grm. substance gave 0.3910 $\text{CaFl}_2 = 24.0\% \text{Fl}$
 II. 0.7778 grm. " " 0.6936 $\text{U}_3\text{O}_4 = 75.5\% \text{U}$
 III. 0.7200 grm. " " 0.6484 $\text{U}_3\text{O}_4 = 76.4\% \text{U}$

The formula UFl_2 requires the following percentage:

Calculated.		Found.		
		I.	II.	III.
U	= 120. 75.9	....	75.5	76.4
Fl ₂	= 38. 24.1	24.0	....	....
	158. 100.0			

PREPARATION III. Hydrofluoric acid acts upon the protoxide of uranium very slowly and yields bifluoride of uranium.* As thus prepared it has the property of passing through filtering paper. No analysis of it was made.

PREPARATION IV. Hydrofluoric acid converts freshly precipitated hydrated protoxide of uranium into the bifluoride immediately. The green precipitate formed also possesses the property of passing through filters. I did not consider an analysis of this necessary.

PREPARATION V. Hydrofluoric acid produces in a solution of the bichloride of uranium UCl_2 a green gelatinous precipitate which is so voluminous that a moderately concentrated solution of the uranium salt solidifies. On adding water and agitating the precipitate it settles; and when washed by decantation or upon the filter retains its gelatinous form. By drying this precipitate however over sul-

* Hans Hermann, in his dissertation already referred to, mentions this reaction but maintains the formation of a "sesquifluoride" which is impossible.

phuric acid *in vacuo* or at 100° C. it diminishes greatly in volume and yields a greenish powder a shade lighter than when prepared by any of the previous methods. Two estimations of the uranium made in the manner already described gave the following results.

1.0308 grm. of the salt dried at 100° C. gave 0.8725 grm. of the proto-sesquioxide, which is equal to 71.8 per cent U; and 0.4460 grm. of the same gave 0.3795 grm. of the green oxide or 72.1 per cent U.

The formula UFl_2 requires 75.9 per cent uranium but the formula $2(\text{UFl}_2) + \text{H}_2\text{O}$ requires 71.8 per cent uranium, and it would appear that this is a hydrate which only imperfectly loses its water at 100° C.

The water estimations made gave however no satisfactory results, and the further examination of this salt was abandoned.

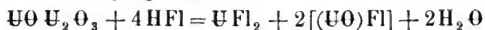
A SUBFLUORIDE (?) was obtained by heating the bifluoride in a current of dry hydrogen. Hydrofluoric acid was given off and a reddish brown powder formed on the surface; by pulverizing the aggregated mass, heating again in hydrogen and repeating the operation several times, the greater portion assumed a reddish color.

This substance is quite insoluble in water and scarcely attacked by acids, concentrated nitric acid excepted. It was not further examined but probably corresponds in composition to the *subchloride* obtained under similar conditions.

OXIFLUORIDE OF URANIUM.

(UO)Fl.

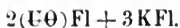
(Old notation, $U_2Fl_3 + 2U_2O_3$). Hydrofluoric acid only partially dissolves the green oxide of uranium; the green bifluoride remaining insoluble may be collected on a filter though as before mentioned the latter cannot be washed out. The yellow solution shows the same reactions as that which Berzelius* obtained by dissolving hydrated sesquioxide of uranium in hydrofluoric acid and is evidently identical with it. Accepting the composition of this body given by Berzelius, viz, (UO)Fl its formation is expressed in the following equation:



No analysis of this salt was made but a few of its properties were examined. The yellow solution is uncrystallizable, and on evaporation yields a nearly white mass which dissolves again in water without decomposing. It is also soluble in alcohol, and on evaporating this solution it furnishes a yellow, transparent, amorphous mass which is very deliquescent. This salt retains water when dried at $100^\circ C$. If heated in a closed tube it is only partially decomposed, the residue being somewhat soluble in hydrochloric acid. When heated on platinum foil, it loses fluorine and the green oxide of uranium remains. Finally, when the solution of the salt is heated with tin and hydrochloric acid, the green bifluoride of uranium is precipitated as already mentioned.

* Poggend. Ann. Vol. I, p. 34.

OXIFLUORIDE OF URANIUM AND FLUORIDE OF POTASSIUM.



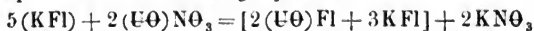
PREPARATION I. Fluoride of potassium added to a solution of the nitrate of uranium produces a heavy crystalline precipitate of a lemon yellow color. This precipitate being but sparingly soluble, may be washed upon a filter with cold water to free it from an excess of fluoride of potassium and from the nitrate of potassium which forms; and being more abundantly soluble in hot water it may be purified by dissolving in hot water and allowing the solution to crystallize, either from the hot concentrated solution or by evaporation of the cold solution over sulphuric acid.

In preparing this salt it is of advantage to use a slight excess of fluoride of potassium,* the salt being soluble in nitrate of uranium. According to the analysis made, the details of which are given below, this salt was found to

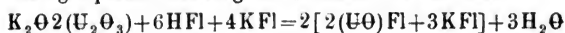
* The fluoride of potassium employed must be free from silico-fluoride of potassium, hence the following precautions observed in its preparation.

Selected crystals of pure fluor spath (as free from quartz as possible) were finely pulverized in an iron mortar and gently heated with concentrated sulphuric acid in a platinum retort. The hydrofluoric acid was absorbed by distilled water contained in a platinum capsule and after the distillation ceased, the acid solution was neutralized with pure carbonate of potassium. If notwithstanding these precautions a small quantity of silico-fluoride of potassium forms, it may be separated by filtering through platinum or gutta-percha funnels.

contain $2(\text{UO})\text{Fl} + 3\text{KFl}$; its formation may be therefore expressed in the following equation:



PREPARATION II. The oxifluoride of uranium and potassium may also be procured by dissolving freshly precipitated uranate of potassium in hydrofluoric acid, adding fluoride of potassium and crystallizing. The necessity of adding fluoride of potassium is made evident by the following equation showing the formation of the salt:



PREPARATION III. The same salt may be procured by adding fluoride of potassium to a solution of the hydrated oxide of uranium in hydrofluoric acid, or to the oxifluoride of uranium as obtained by the action of hydrofluoric acid on the green oxide of uranium. These methods however possess no advantages over the foregoing.

In the hope of preparing the salt in question in the dry way, I made the following experiment. A small quantity of the double salt sulphate of uranium and potassium was prepared by heating the nitrate of uranium with concentrated sulphuric acid and neutralizing with potassa. This double salt was finely pulverized, intimately mixed with fluoride of sodium and some previously dried sulphate of sodium (as a flux), the mixture introduced into a Hessian crucible which was maintained at a red heat for more than an hour and then allowed to cool in the furnace. The result however was unsatisfactory; the greater part of the sulphate of uranium and potassium remained unchanged, with the exception of the formation of a small amount of uranate of sodium near the surface of the melted mass.

PROPERTIES. The oxifluoride of uranium and potassium crystallizes in small yellow plates. I obtained crystals grouped in three different ways: *first*, by the cooling of a hot concentrated solution, a crust of minute crystals formed upon which rested larger individual prisms; *secondly*, by the *spontaneous* evaporation of a cold solution well defined twin crystals formed, easily distinguishable without a magnifying glass though not more than two millimeters in diameter; *thirdly*, I accidentally obtained a number of warty concretions consisting of concentric rings of small crystals and completely spherical. They formed at a low temperature. The crystals thus obtained are small but often well formed and possess a high lustre but not the brilliant *fluorescence* peculiar to the corresponding oxichloride. Containing no chemically combined water they do not effloresce.

I am indebted to Prof. Victor von Lang, who had the kindness to measure crystals of this salt, for the following data.

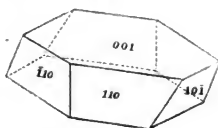
Crystalline system: Monoclinic.

$$a : b : c = 1.375 : 1 : 3.477 \quad *$$

$$ac = 99^{\circ} 40'$$

Observed forms = (001), (110), ($\bar{1}01$). Fig. 1.

Calculated	Observed
$001.\bar{1}01 = 77^{\circ} 0'$	$77^{\circ} 0'$
$001.110 = 82^{\circ} 14'$	$82^{\circ} 14'$
$110.\bar{1}10 = 72^{\circ} 50'$	$72^{\circ} 50'$
$110.10\bar{1} = 56^{\circ} 47'$	58°



The crystals as seen in fig. 1 are plates, the planes (001) predominating.

The twin crystals of the same salt furnished the following.

Crystalline system: Tetragonal.

$$a : c = 1 : 2.0815$$

Thus, 8.6812 grms of the concentrated solution at 21° C yielded on evaporation 0.9653 grm. of the salt. By calculation, therefore, 100 parts of water at 21° C dissolve 12.5 parts of the salt.

The salt is decomposed by melting with carbonate of sodium, forming uranate and fluoride of sodium. The action of reagents on the solution of the salt is as follows: *ammonia* produces the usual precipitate of uranate of ammonium; the *carbonates of sodium and ammonium* do not decompose the salt on boiling; *chloride of barium* gives even in dilute solutions a voluminous white precipitate which settles in the form of a crystalline powder; this change is accelerated by heating; *acetate of lead* gives an orange yellow precipitate very soluble in dilute acids, the filtrate still contains uranium; *chloride of calcium* gives a white transparent precipitate from which it is impossible to filter; solutions of *silver, copper, iron, mercury, platinum and zinc* are without action; *oxalic or formic acids* and the *direct rays of the sun* produce a green precipitate.*

By heating the salt in a current of hydrogen gas, hydrofluoric acid is disengaged and the greenish residue consists of a mixture of bifluoride of uranium, *protoxide of uranium* and fluoride of potassium. This experiment demonstrates most clearly the presence of oxygen.

QUANTITATIVE ANALYSIS. (a) The crystallized salt having been dried over sulphuric acid, a weighed portion was heated in a platinum crucible with concentrated sulphuric acid and when the fluorine was completely expelled the excess of acid evaporated. The temperature was gra-

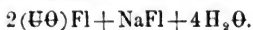
* See page 33.

dually raised until the crucible was at a low red heat, its contents melting without projections. After dissolving out the contents of the crucible, ammonia was added to throw down the uranium and this precipitate treated as usual. Since uranate of ammonium precipitated in presence of the fixed alkalies has a tendency to combine with them, the green oxide of uranium after having been weighed was dissolved in nitric acid and reprecipitated by ammonia, washed, ignited and weighed as before. The second weighing showed a loss of twelve tenths of a milligramme (0.0012 grm.) which is too inconsiderable to affect the analysis and is to be attributed to inaccuracy of manipulation rather than to the presence of potassa in the first precipitate.

(b) The filtrate was evaporated to dryness in a platinum dish on a water-bath, the residue gently calcined until all chloride and sulphate of ammonium were expelled and the remaining sulphate of potassium was dissolved in a few drops of water filtered into a platinum crucible, again evaporated, ignited and weighed. Since it is necessary to wash the uranate of ammonium with a dilute solution of chloride of ammonium, the estimation of the potassium as just detailed is exceedingly tedious.

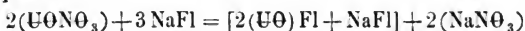
(c) The determination of the fluorine presented many difficulties. The precipitate of fluoride of calcium obtained by adding chloride of calcium to the solution of the potassium salt is in an extremely fine state of division and runs through the filter notwithstanding every precaution. The estimation of the fluorine as fluoride of lead was not deemed sufficiently accurate or available in this case, and the following method was pursued which though imperfect gave such results as warranted its use. A weighed quantity

OXIFLUORIDE OF URANIUM AND FLUORIDE OF SODIUM.

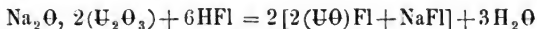


I. This salt though more difficult to procure than the foregoing, crystallizes far better if one succeeds in employing the proper proportions of its constituents.

By evaporating a mixture of nitrate of uranium and fluoride of sodium in a desiccator, I obtained monoclinic prisms of considerable size and great beauty, but many trials subsequently made were unsuccessful in reproducing them. The analysis having given the above constitution of the double salt, its formation may be expressed by the equation:



A solution of uranate of sodium in hydrofluoric acid when slowly evaporated over sulphuric acid furnishes similar crystals, but neither in this case could I find the conditions requisite for their certain formation. This method should theoretically be more advantageous than the previous one in which nitrate of sodium forms and interferes with the crystallization but it did not prove as successful. The reaction is as follows:



PROPERTIES. This salt is by no means so stable as the corresponding potassium salt; it decomposes on attempting to recrystallize it, or if its solution is heated, fluoride of sodium crystallizing out separately.

Prof. Victor von Lang who also measured these crystals has furnished the following data.

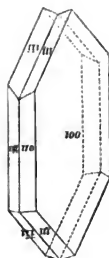
Crystalline system: monoclinic.

$a : b : c = 1.0272 : 1 : 0.5222$. $\alpha c = 94^\circ 51'$

Observed forms: (100), (110), ($\bar{1}11$), ($\bar{1}32$)

Fig. 3.

Calculated	Observed
$110 \cdot 100 = 45^\circ 40'$	$45^\circ 40'$
$\bar{1}11 \cdot \bar{1}00 = 69^\circ 20'$	$69^\circ 20'$
$\bar{1}11 \cdot \bar{1}\bar{1}1 = 51^\circ 20'$	$51^\circ 20'$
$\bar{1}11 \cdot \bar{1}10 = 56^\circ 11'$	55°
$\bar{1}32 \cdot 100 = 97^\circ 41'$	98°
$\bar{1}32 \cdot \bar{1}10 = 58^\circ 19'$	60°



The crystals are juxtaposition twins on the plane (100) and as seen in fig. 3 appear as thin plates by the predominance of the same plane.

When heated in a closed tube, it gives off its water of crystallization, and on raising the temperature melts, the residue consisting of uranate of sodium. In a dry atmosphere it effloresces. Its properties in general resemble those of the potassium salt, and the analysis was simply a repetition of that described at length in the preceding section.

When the crystallized salt is heated at 100°C . it loses two atoms of water = 8.4 per cent.

I. 1.2230 grms. cryst. salt gave 0.8205 $\text{U}_3\text{O}_4 = 56.9\% \text{U}$

1.2230 " " " " 0.2340 $\text{Na}_2\text{SO}_4 = 6.2\% \text{Na}$

The formula $2(\text{UO})\text{Fl} + \text{NaFl} + 4\text{H}_2\text{O}$ requires the following percentage:

	Calculated.	Found.
$\text{U}_2 = 240,$	56.6	56.9
$\text{O}_2 = 32,$	7.54	....
$\text{Fl}_3 = 57,$	13.44	....
$\text{Na} = 23,$	5.42	6.2
$4\text{H}_2\text{O} = 72,$	17.0	....
	<u>424</u> <u>100.00</u>	

II. On endeavoring to recrystallize this salt it partially decomposes, and other smaller crystals form containing two atoms less of water. This salt is not efflorescent.

The analysis gave the following results:

- I. 1.0755 grms. cryst. salt gave 0.7765 grm. $\text{U}_3\text{O}_8 = 61.3\% \text{U}$
 II. 0.8699 " " " " 0.2730 grm. $\text{CaF}_2 = 15.1\% \text{F}$

These figures correspond to the formula $2(\text{UO})\text{F} + \text{NaF} + 2\text{H}_2\text{O}$ as follows:

	Calculated.	Found.
$\text{U}_2 = 240,$	61.85	61.3
$\text{O}_2 = 32,$	8.24	....
$\text{F}_2 = 57,$	14.69	15.1
$\text{Na} = 23,$	5.92	....
$2\text{H}_2\text{O} = 36,$	9.30	....
	388, 100.00	

OXIFLUORIDE OF URANIUM AND FLUORIDE OF AMMONIUM.



By dissolving uranate of ammonium in hydrofluoric acid and evaporating the solution over sulphuric acid, but few distinct crystals were obtained. On account of the difficulty of preparing this salt in a pure state no quantitative analysis of it was made, but only a few of its properties examined.

This yellowish imperfectly crystallized mass is very soluble in water, less soluble in a solution of hydrofluoric acid and quite insoluble in alcohol. When heated on platinum foil it is completely decomposed the green oxide

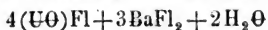
remaining. When heated in a closed tube, water is at first given off, fluoride of ammonium sublimes and condenses on the sides of the tube. The residue in this case is also the proto-sesquioxide of uranium.

This salt has most probably a composition corresponding to the foregoing salts of potassium and sodium, which may be expressed in general terms as follows: $x(U\Theta)Fl + yRFl + zH_2\Theta$. "R" being the alkali metal.

OXIFLUORIDE OF URANIUM

AND

FLUORIDE OF BARIUM.



PREPARATION. The addition of chloride of barium to a solution of the oxifluoride of uranium and potassium produces a voluminous lemon yellow precipitate which gradually settles in the form of a crystalline powder. This precipitate being quite insoluble in cold water may be washed on the filter until free from chloride of barium and when dried at 100° C. forms a yellowish white powder which under a powerful microscope resolves into minute crystals. If, in preparing this salt, the oxifluoride of uranium and potassium is not perfectly free from fluoride of potassium, the insoluble uranium salt will be mixed with fluoride of barium which being equally insoluble cannot be separated.

PROPERTIES. Hot water dissolves only a trace of this salt, but it is quite soluble in dilute acids. This acid solution yields a white precipitate of sulphate of barium with sulphuric acid, and the filtrate a yellow precipitate

of uranate of ammonium with ammonia. On heating the salt in a closed tube, water is disengaged, and at a higher temperature hydrofluoric acid. The salt does not melt during the decomposition.

ANALYSIS. The quantitative analysis was conducted as follows; a given quantity was dissolved in dilute hydrochloric acid, and the solution being heated to boiling, the barium was thrown down with a slight excess of sulphuric acid. The uranium was precipitated by ammonia and estimated as U_3O_4 . The fluorine was estimated in the filtrate in the same manner as in the analysis of the preceding salts. The salt dried at 100° C. still retains water which was estimated according to a method proposed and employed by Berzelius and recommended by H. Rose.* A weighed quantity of the salt was introduced into a porcelain crucible and well mixed with four to five times its weight of previously calcined litharge. The crucible was weighed first empty then with the salt and then after the addition of the oxide of lead; the covered crucible was cautiously brought to a low red heat and after cooling in the desiccator was weighed again. The difference in weight before and after calcining is due to the water driven off, the fluorine being retained by the lead.

Result of the analyses:

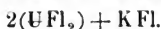
I.	0.7222	gram.	substance	gave	$0.4178 BaSO_4 = 33.9\% Ba$
	"	"	"	"	$0.3564 U_3O_4 = 41.8\% U$
II.	0.6427	"	"	"	$0.3720 BaSO_4 = 35.3\% Ba$
	"	"	"	"	$0.3140 U_3O_4 = 41.1\% U$
	"	"	"	"	$0.2110 CaF_2 = 15.9\% Fl$
III.	0.5538	"	"	"	$0.0192 H_2O = 3.4\% H_2O$

* Chimie Analytique. Vol. II, p. 758.

The formula $4(\text{U}\Theta)\text{Fl} + 3\text{BaFl}_2 + 2\text{H}_2\Theta$ corresponds to the figures obtained as follows:

Calculated.		Found.		
		I.	II.	III.
$\text{U}_4 = 480,$	40.6	41.8	41.1	....
$\Theta_4 = 64,$	5.4	....	....	....
$\text{Fl}_{10} = 190,$	16.1	....	15.9	....
$\text{Ba}_3 = 411,$	34.8	33.9	35.3	....
$2\text{H}_2\Theta = 36,$	3.1	....	....	3.4
	1181.			
	100.0			

FLUORIDE OF URANIUM AND POTASSIUM.



PREPARATION. Formic acid produces no precipitate in the solution of the oxifluoride of uranium and potassium, but if the acidified solution is placed in the direct rays of the sun decomposition begins almost immediately; a green precipitate gradually falls, and if the action is prolonged, the solution becomes colorless and retains only a trace of uranium.

The precipitate washed upon a filter and dried at 100°C forms a green impalpable powder much resembling the bifluoride of uranium. This reaction appears to be best effected in dilute solutions.

PROPERTIES. This double fluoride is quite insoluble in water and in dilute acids. It dissolves with difficulty in concentrated boiling hydrochloric acid, but is more easily decomposed with concentrated sulphuric acid which expels the fluorine and yields a green solution. Ammonia produces in this solution a black precipitate of hydrated

protoxide of uranium and the filtrate on evaporation yields sulphate of potassium.

When heated on platinum foil the salt melts, hydrofluoric acid is disengaged and the yellow residue consists of uranate of potassium. This reaction distinguishes this double salt in a marked manner from the bifluoride. When heated in a closed tube, i. e. without access of air, the decomposition is different. The salt melts and gives off hydrofluoric acid as before, but the residue consists of black protoxide of uranium suspended in fused fluoride of potassium. If heated with a solution of caustic soda, it is decomposed with formation of the black protoxide, while the fluorine goes into solution. When heated in a current of dry hydrogen, it melts, hydrofluoric escapes and the same reddish powder is formed which was obtained by treating the bifluoride of uranium in a similar manner. On cooling the mass was found to be green within, the surface only having been attacked. No further examination of this was made.

ANALYSIS. The analysis of this salt was made in exactly the same manner as that of the oxifluoride, only remarking that the solution in sulphuric acid was oxidized with fuming nitric acid before throwing down the uranium with ammonia. The potassium was estimated in the ordinary way as sulphate.

The following figures show the results of the analysis.
 0.7535 grm substance gave 0.5640 grm $U_3O_4 = 63.4\% U$
 " " " " 0.1852 " $K_2SO_4 = 11.0\% K$

The formula $2(UFl_2) + KFl$ requires the following percentage:

	Calculated.	Found.
U ₂ = 240.	64.1	63.4
Fl ₃ = 95.	25.5	...
K = 39.	10.4	11.0
	<u>374.</u>	<u>100.0</u>

QUANTITATIVE REDUCTION OF THE OXIFLUORIDE OF URANIUM AND POTASSIUM.

As already remarked the reducing action of formic acid in the sunlight is very complete so that only a trace of uranium remains in solution, and the resulting salt being quite insoluble I conceived the idea of effecting the reaction *quantitatively*, and as the figures below indicate, succeeded beyond expectation.

The method of making this *quantitative analysis by means of the sunlight* needs no lengthy description. A quantity of the potassium double salt was dried at 100° C, weighed, dissolved in water acidified with formic acid and the solution exposed to the direct rays of the sun during two (short winter) days. So long a time was necessary for although decomposition begins at once and is at first rapid it gradually decreases in intensity as the solution becomes weak. The green precipitate was collected on a filter previously dried at 100° C and weighed and after being washed with cold water, the filter and contents were dried at 100° C and weighed as before. Thus two weighings sufficed to give data for calculating the formula of the salt and at the same time to confirm the formula adopted for the oxifluoride.

1.0635 grm. oxifluoride gave 0.8205 grm. of the precipitate.

Weight of salt employed is to its equivalent as weight of precipitate is to its equivalent

$$1.0635 : 484 = 0.8205 : x$$

$$x = 373.6$$

The formula $2(\text{UFl}_2) + \text{KFl}$ has the equivalent = 374.0

A second analysis was made in like manner. 1.1530 grm. of the oxifluoride gave 0.8783 grm. of the precipitate. In place of stating the proportion as above it may also be put thus:

Equiv. of oxifluoride is to equiv. of double fluoride as weight of oxifluoride is to weight of precipitate

$$484. : 374. = 1.1530 : x$$

$$x = 0.8888 \text{ grm.}$$

whereas the weight actually received = 0.8783 grm.

REDUCTION OF THE OXIFLUORIDE OF URANIUM AND POTASSIUM BY MEANS OF OXALIC ACID AND SUNLIGHT.

Oxalic acid with the aid of sunlight decomposes the oxifluoride of uranium and potassium in much the same manner as formic acid, but with the formation of secondary products. The green insoluble fluoride of uranium and potassium falls as before, but after the decomposition has reached a certain stage, a brownish red precipitate also forms.

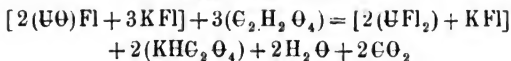
This proved to be hydrated protoxide of uranium, discovered by Ebelmen* and obtained by him through the

* Annal. d. Chem. u. Pharm. Vol. XLIII.

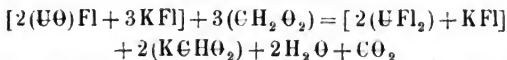
action of the sun's rays on a solution of the oxalate of uranium. This hydrate however being soluble in dilute acids is easily separated from the quite insoluble fluoride.

During the decomposition by oxalic acid a considerable quantity of carbonic acid disengages; of course carbonic acid must be also set free when the decomposition is effected with formic acid, but only half as much is theoretically formed and this is probably absorbed by the water for in no case did I observe its escape. The following equations giving the action of these two acids are probably not absolutely correct but only approximatively so, since Ebelmen mentions the formation of carbonic oxide as well as of carbonic acid.

With oxalic acid:



With formic acid:



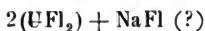
An experiment made with the object of effecting the reduction at a high temperature without the aid of sunlight, was unsuccessful. A solution of the oxifluoride acidified with formic acid was heated in a sealed tube at 100° C. and afterwards at 120° C. but without producing the least change.

In a sealed tube which stood for several weeks in diffuse daylight a small quantity of the green precipitate formed, the glass being at the same time somewhat attacked by the fluorine. On opening the tube carbonic acid gas escaped from the solution.

The oxichloride of uranium and potassium corresponding

to the fluorine salt and having the formula $(UO)Cl + KCl + 2aq$ could not be reduced by means of formic or oxalic acids in the sunlight; nor by heating an acidified solution in a sealed tube at $120^{\circ} C$.

FLUORIDE OF URANIUM AND SODIUM.



When a solution of the oxifluoride of uranium and sodium is acidified with formic or oxalic acids and exposed to the direct rays of the sun, a reduction takes place in much the same manner as in the case of the potassium salt. The properties too of the precipitate differ little from those of the corresponding potassium compound, but it appears to be somewhat soluble in water since the solution becomes green and not colorless after a lengthened exposure. Neither does it melt when heated on platinum foil but simply loses fluorine and leaves uranate of sodium characterized by its yellow color. I made no analysis of this salt, but it probably possesses the composition given in the above formula.

As much as the application of Pélignot's uranyle theory simplifies the formulae of many compounds of uranium they become still more simple when combined with the modern double atomic weights and the unitary system of notation. The following table of a few of the most important salts of uranium gives in the first column the old names and formulae and in the second the new.

Uranium	U = 60	Uranium	U = 120
Protoxide	UO	Protoxide	$\text{U}^\oplus\text{O}$
Sesquioxide	U_2O_3	Sesquioxide	$\text{U}_2^\oplus\text{O}_3$
Sulphide	US	Sulphide	$\text{U}^\oplus\text{S}$
Ox sulphide	$\text{U}_2\text{O}_2\text{S}$	Sulphide of uranyle	$(\text{U}^\oplus\text{O})_2\text{S}$
Protochloride	UCl	Bichloride	$\text{U}^\oplus\text{Cl}_2$
Oxichloride	$\text{U}_2\text{Cl}_3 + 2\text{U}_2\text{O}_3$	Chloride of uranyle	$(\text{U}^\oplus\text{O})\text{Cl}$
Oxichloride of uranium and chloride of potassium	$\text{KCl} + \text{U}_2\text{O}_3\text{Cl} + 2\text{aq}$	Chloride of uranyle and potassium	$\text{KCl} + (\text{U}^\oplus\text{O})\text{Cl} + \text{H}_2\text{O}$
Protofluoride	UF	Bifluoride	$\text{U}^\oplus\text{F}_2$
Oxifluoride	$\text{U}_2\text{F}_3 + 2\text{U}_2\text{O}_3$	Fluoride of uranyle	$(\text{U}^\oplus\text{O})\text{F}$
Oxifluoride of uranium and fluoride of potassium	$2(\text{U}_2\text{O}_3\text{F}) + 3\text{KF}$	Fluoride of uranyle and potassium	$2(\text{U}^\oplus\text{O})\text{F} + 3\text{KF}$
Oxifluoride of uranium and fluoride of sodium	$2(\text{U}_2\text{O}_3\text{F}) + \text{NaF} + 8\text{H}_2\text{O}$	Fluoride of uranyle and sodium	$2(\text{U}^\oplus\text{O})\text{F} + \text{NaF} + 4\text{H}_2\text{O}$
Sulphate of protoxide	UOSO_3	Sulphate of uranium	$\text{U}^\oplus\text{SO}_4$
Sulphate of sesquioxide	$\text{U}_2\text{O}_3\text{SO}_3$	Sulphate of uranyle	$(\text{U}^\oplus\text{O})\text{SO}_4$
Nitrate of sesquioxide	$\text{U}_2\text{O}_3\text{NO}_3$	Nitrate of uranyle	$(\text{U}^\oplus\text{O})\text{NO}_3$
etc.		etc.	

On comparing the chlorine with the fluorine compounds (the bromides and iodides being as yet too little studied) the most marked difference is the greater *stability* of the latter. While the bichloride of uranium is volatile, very soluble and even deliquescent, the corresponding fluoride is not in the least volatile and is quite insoluble in water.

The double salts of potassium too show the same distinctive character. The chloride of uranyle and potassium is obtained with greater difficulty and cannot be recrystallized, while the fluorine salt forms easily and crystallizes repeatedly from its solutions.

It is certainly remarkable that while the fluorine salt exhibits such a sensibility to the sun's rays (in presence of a reducing agent) the chlorine salt does not possess this in the smallest degree. Might not this double fluorine salt be employed to estimate the power of the sun's actinic rays? For as we have seen, the green precipitate which forms only in the sunshine is so insoluble as to admit of effecting the reaction quantitatively.

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TO THE

LITERATURE OF URANIUM.

Henry
BY H. CARRINGTON BOLTON.

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Index to the Literature of Uranium.

By H. CARRINGTON BOLTON.

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DATE.	AUTHOR.	REMARKS.	REFERENCES.*
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1789	Crell.....		J. de Phys., XXXV., 391.
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1800	Ritter.....	Magnetic properties....	Gilbert Ann., IV., 24.
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1823	H. Rose.....	Sulphide.....	Gilb. Ann., LXXIII., 139.

* For explanation of abbreviations, see Introduction to Dana's Mineralogy, 5th edition.

DATE.	AUTHOR.	REMARKS.	REFERENCES.
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1825	Berthier.....	Oxide.....	Ann. d. M. <u>[1]</u> , X., <u>141</u> .
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1831	Berzelius.....	Vanadate.....	Pogg. Ann., XXII., <u>63</u> .
1832	Herschel.....	Separation from iron by K_2FeCy_3	Ann. Ch. Phys., XLIX., 810; Pogg. Ann., XXV., 627; Berz. Jahresb., XIII., <u>120</u> .
1834	Persoz.....	Separation by acetate lead.....	Ann. Ch. Phys. <u>[2]</u> , LVI., 333; J. pr. Ch., 1834, III., 216; L'Institut, No. <u>70</u> , 299; Berz. Jahresb., XV., 195; Pogg. Ann., XXXIII., 248.
.....	Persoz.....	Separation by CuO and HgO.....	Ann. Ch. Phys. <u>[3]</u> , LVIII., 202.
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1835	Berzelius.....	Pyroracemate.....	Pogg. Ann., XXXVI., <u>24</u> .
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1837	Marchand.....	Sulphethylate.....	J. pr. Ch., XII., 264; Pogg. Ann., XLI., 629.
1838	Werner.....	Extraction.....	Ann. Ch. Pharm., XXVIII., 240; J. pr. Ch., XII., 381; Dingl. J., LXVIII., 465.
1841	Regnault.....	Specific heat.....	Ann. Ch. Pharm., XXXVI., <u>108</u> ; Berz. Jahresb., XXI., <u>13</u> .
1841	Plantamour.....	Attempt to reduce protoxide.....	J. pr. Ch., XXIII., 230; Pharm. Centr., 1841, 592.

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1841	Wöhler.....	Vd. in Uranpecherz.....	Pogg. Ann., LIV., 600.
1841 to 1842	Péligot.....	Metallic U. and general researches.....	C. R., April, 1841. p. 735 ; J. pr. Ch., XXIII., 494 ; XXIV., 442 ; J. d. Pharm., XXVII., 525 ; Ann. Ch. Phys. [3], V., 1 ; Ann. Ch. Pharm., XLI., 141.
1841 to 1842			Ann. Ch. Pharm., XLIII., 255 ; Pharm. Centr., 1842, 321 and 847 ; Berz. Jah- resb., XXII., 113 ; XXIII ; Pogg. Ann., LIV., 122.
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1842	Wittstein.....	Extraction.....	Buchner's Repert., LXIII., 231.
1842	Delffs.....	Carbonate, &c.....	Pogg. Ann., LV., 229 ; Berz. Jahresb., XXIII., 201.
1842	Wöhler.....	Preparation of cryst. UO	Ann. Ch. Pharm., XLI., 345 ; Berz. Jahresb., XXIII.
1842	Kühn.....	Criticism on Péligot....	Ann. Ch. Pharm., XLI., 337 ; Pharm. Centr., 1842, 324.
1842	Fresenius.....	Cyanide.....	Ann. Ch. Pharm., XLIII., 135.
1842	Wertheim.....	Acetates.....	Monatsb. d. Berl. Akad., 1842 ; J. pr. Ch., XXIX., 209 ; Ann. Ch. Pharm., XLIV., 274 ; Ann. Ch. Phys. [3], XI., 49 ; Pharm. Centr., 1843, 585 ; Pogg. Ann., LVII., 481.
1843	Rammelsberg.....	Bromate.....	J. pr. Ch., XXIV., 285 ; Berz. Jahresb., XXII., 140.
1843	Berthier.....	Sulphite and separation	Ann. Ch. Pharm., XLVI., 184 ; Pharm. Centr., 1843, 382.
1843	Bonaparte.....	Valerianate.....	J. pr. Ch., XXX., 308 ; Pharm. Centr., 1843, 949.
1843	Köhnke.....	Technical uses.....	Wiener Polyt. J., 1843, 1117.
1843	Malaguti.....	Hydrated sesquioxide..	Ann. Ch. Pharm., XLVIII., 236 ; Ann. Ch. Phys., IX., 463 ; J. pr. Ch., XXIX., 231 ; C. R., XVI., 851 ; Pharm. Centr., 1843, 590 ; Berz. Jahresb., XXIV., 118.

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1844	Bottinger.....	Separation.....	Ann. Ch. Pharm., LI., 407; Pharm. Centr., 1845, 107 .
1846	Berzelius.....	Extraction.....	Berz. Jahresb., XXV., 162.
1846	Peters.....	Extraction.....	Arch. d. Pharm., XLVII., 146 ; Pharm. Centr., 1846, 831.
1847	Arppe.....	Pyrotartrate.....	Inaug. Diss., Helsingf., 1847; Ann. Ch. Pharm., LXVI., 73 .
1848	Werther.....	Phosphates & arsenates	J. pr. Ch., XLIII., 321; XLIV., 127 ; Ann. Ch. Pharm., LXVIII., 312 ; Pharm. Centr., 1848, 433; Instit., 1848, 393; J. d. Pharm. [3] , XIV., 57 ; Phil. Mag. [3] , XXXIII., 244; Jahresb., 1849, 418 and 1218.
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1849	Patera.....	Extraction on large scale	Wien. Acad. Ber., 1849, 353; Wien. Ber. Freund. d. Wiss., IV; J. pr. Ch., XLVI., 182; Jahresb., 1849, 274, 584.
1850	Patera.....	Red sulphide.....	J. pr. Ch., LI., 122 ; Ann. Ch. Pharm., LXXXVI., 254; Pharm. Centr., 1851, 402; Jahresb., 1850, 313.
1852	Stokes.....	Fluorescence of uranium glass.....	Phil. Mag. [4] , IV., 388; Pogg. Ann., LXXXVII., 488; Am. J. Sci. [2] , XV., 270; Jahresb., 1853, 140 .

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1852	Stokes.....	Detection U.....	C. R., XXXIV., 22 ; Ann. Ch. Ph., LXXXI., 366; Pharm. Centr., 1852, 100 .
1852	Girard.....	Sulphite.....	Jahresb., 1852, 433.
1852	Schabus.....	Crystallographic.....	Wien. Acad. Ber., XI., 842; J. pr. Ch., LXI., 397; Pharm. Centr., 1854, 236; Dingl. J., CXXXII., 36 ; Chem. Gaz., 1854, 178 ; Jahresb., 1853, 740.
1853	Patera.....	Extraction on large scale	J. pr. Ch., LXV., 349; Pharm. Centr., 1855, 605; Phil. Mag. [4] , X., 390; Jahresb., 1855, 133 .
1855	Werther.....	Fluorescence.....	Chem. Gaz., 1855, 450; Pharm. Centr., 1856, 47 .
1855	C. Gr. Williams...	Oxychloride and organic bases.....	Dingl. J., CXLI., 372; Pharm. Centr., 1856, 843; Polyt. Centr., 1857, 75 ; J. pr. Ch., LXIX., 118 ; Oestr. Zeits. Berg u. Hüt., 1856, 31 .
1856	Patera	Purification of U. yellow	J. pr. Ch., LXIX., 401; Pharm Centr., 1856, 738 and 803; Jahresb., 1856, 728.
1856	Knop.....	Estimation	Pharm. Centr., 1856, 717.
1856	Scheibler.....	Acetate of U ₂ O ₃ and LiO	Pogg. Ann., XCIX., 275; Jahresb., 1856, 380; J. pr. Chem., LXIX., 303.
1856	Keferstein.....	Crystallographic.....	C. R., XLII., 73 ; Instit., 1856, 29 ; J. d. Pharm. [3] , XXIX., 203; Ann. Ch. Pharm., XCVII., 256; Pogg. Ann., XCVII., 630 ; J. pr. Ch., LXVIII., 184; Pharm. Centr., 1856, 223; Jahresb., 1856, 380; Phil. Mag., 1857, 123 .
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1857	Kessler.....	Extraction	

DATE.	AUTHOR.	REMARKS.	REFERENCES.
1857	Arendt and Knop..	Extraction	Pharm. Centr., 1857, 162; J. pr. Ch., LXXI, 68; Jahresb., 1857, 200.
1858	Marbach	Optical examination....	Pogg. Ann., CIV., 422.
1858	Weselsky.....	Acetates.....	Chem. Gaz., 1858, 390; J. pr. Ch., LXXV., 55; Pharm. Centr., 1858, 610.
1858	Brianchon.....	Technical uses.....	Génie Indust., 1858, 147; Technologiste, 1858, 521; Polyt. Centr., 1858, 1242; Dingl. J., CXLVIII., 172; Chem. Centr., 1858, 698; Polyt. Centralhalle, 1858, 670.
1859	Hallwachs & Scharfariik	Action of U. on iodide ethyle	Ber. Acad. Wiss. Wien, XXXIII., 569; Pharm. Centr., 1859, 163.
1859	Pincus	Estimat'n of phosphoric acid with acetate of U.	J. pr. Ch., LXXVI., 104.
1859	Wysocky.....	Extraction on large scale	Oest. Zeitschr. Berg. Hüt., 1859; Dingl. J., CLV., 305; Pharm. Centr., 1860, 327; Polyt. Centr., 1860, 139; Jahresb., 1860, 698.
1860	Anthou.....	Extraction	Dingl. J., CLVI., 207 and 288; Zeitschr. Ch. Pharm., 1860, 412; Rep. Chim. Appl., II., 281; Pharm. Centr., 1860, 549 and 591; Polyt. Centr., 1860, 1118 and 1274.
1861	Drenkmann.....	Historical résumé and researches.....	Zeitschr. ges. Naturw., XVII., 113; Jahresb., 1861, 255.
1861	H. Hermann.....	Researches.....	Inaug. Dissert. Göt., 1861; Jahresb., 1861, 258.
1861	Fresenius.....	Estimation.....	J. pr. Ch., LXXXII., 257; Chem. News, 1861, 150.
1861	Graham.....	Saccharate.....	Ann. Ch. Pharm., CXXI., 52; Jahresb., 1861, 77.
1861	Pisani.....	Estimat'n and min. anal.	C. R., LII., 72 and 817; Rep. Chim. Pur., III., 222 and 639; Zeitschr. Ch. Pharm., 1861, 123; J. pr. Ch., LXXXV., 186; Pharm. Centr., 1861, 221; Chem. News, III., 211; Jahresb., 1861, 1030 and 824.
1862	Vogelsang.....	Technical.	Preuss. Zeitschr. Berg. H. ü. Salin., X., 168.

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1862	H. Rose.....	Estimation.....	Pharm. Centr., 1862, 863; Jahresb., 1862, 601.
1862	Brachet.....	Use of U. glass.....	C. R., LV., 409.
1862	Parkmann.....	Carbonate.....	Am. J. Sci. [2], XXXIV., 321; Chem. News, 1863, 122; Pharm. Centr., 1864, 465.
1863	Guyard.....	Volumetric estimation..	Bull. Soc. Chim., 1864, I., 94; Jahresb., 1863, 692; Chem. News, 1864, 13; Zeitschr. anal. Ch., III., 376.
1864	Stolba.....	Estimat'n, silico-fluoride	Zeitschr. Anal. Ch., III., 71; Pharm. Centr., 1864, 1053; Jahresb., 1864, 718.
1864	Remelé.....	Oxysulphide.....	C. R., LVIII., 716; Bull. Soc. Chim. [2], I., 36; N. Arch. Ph. Nat., XX., 52; Ann. Ch. Pharm. Suppl., III., 196; Pogg. Ann., CXXIV., 114; J. pr. Ch., XCIII., 316; Pharm. Centr., 1864, 596; Chem. News, X., 123 and 158; Jahresb., 1864, 234.
1865	Von Hauer...	Acetate.....	Pogg. Ann., CXXV., 149; Pharm. Centr., 1865, 735.
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1865	Remelé.....	Oxysulphide.....	Pogg. Ann., CXXV., 209; Zeitschr. Anal. Ch., IV., 371; Zeitschr. Ch., 1865, 548; 1866, 471; J. pr. Ch., XCVII., 193 and 210; Jahresb., 1865, 221 and 726; Pharm. Centr., 1866, 628.
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1866	Elsner.....	Volatility of U_2O_3	J. pr. Chem., XCIX., 260.
1866	Bunsen.....	Flame reactions.....	Ann. Ch. Ph., CXXXVIII., 291.
1866	Wysocky.....		Oestr. Zeit. Berg. Hüt., 1866; Polyt. Centr., 1866, 1601.

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1866	Bolton.	Fluorides.	Berl. Akad. Ber., 1866, 299; Inaug. Diss., Göttingen, 1866; Bull. Soc. Chim. [2], VI., 450; Zeitschr. Ch. [2], II., 353; J. pr. Ch., XCIX., 269; Pharm. Centr., 1866, 977; N. Arch. Ph. Nat., XXVI., 338; Jahresb., 1866, 209.
1867	Skey.	Sulphocyanide.	Chem. News, XVI., 201; Zeitschr. Chem. [2], IV., 123.
1867	Souchay.	Estimation.	Zeitschr. Chem. [2], IV., 527; Zeitschr. anal. Chem., VI., 400.
1867	Scheller.	Sulphites.	Ann. Ch. Pharm., CXLIV., 238; J. pr. Chem., CIV., 56; Zeitschr. Chem., 1867, 522; Bull. Soc. Chim. [2], VIII., 417.
1867	Ed. Becquerel.		Etudes Chim. sur quelq. Métaux, chez Hachette, Paris, 1867.
1869	Péligot.	Metallic U.	C. R., LXVIII., 507; Ann. Ch. Pharm., CXLIX., 128.
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1870	Sorby.	Spectrum of compounds of Zr and U.	Chem. News, April, 1870.

ACTION OF LIGHT.—PHOTOGRAPHY.

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1805	Bucholz.....	Sulphate and alcohol. nitrate and ether....	} See previous section.
....	Gehlen.....	Oxychloride.....	
1841	Ebelmen.....	Oxalate, sulphate.....	
1842	Bonaparte.....	Valerianate.....	
1857	Burnett.....	Photogr. prints.....	Liverpool J. Phot., 1857 and 1858; Humphrey's J., 1857, 81; 1858, 44.
1858	Niepce de St. Victor	Absorption of light and use in printing.....	C. R., XLVI., 449; Instit., 1858, 73; Dingl. J., CXLVIII., 126; J. pr. Ch., LXXIV., 233.
....	"	.....	C. R., XLVII., 806; Humphrey's J., 1858, 10; Dingl. J., CLI., 130; Jahresb., 1858, 20.
1859	"	.....	C. R., XLIX., 815; Dingl. J., CLV., 456; Jahresb., 1859, 33.
....	"	.....	Cosmos, XIV., 568; Polyt. Centr., 1859, 889 and 1032.
1858	Crespon and Godefroy.....	.....	Polyt. Centr., 1858, 1509; Humphrey's J., 1858, 172.
1858	Hagen.....	Photographic printing..	Ber. Akad. Wiss. Berl., 1858, 290; Brit. J. Phot., V., 75; Humphrey's J., 1858, 262; J. pr. Ch., LXXIV., 67; Dingl. J., CXLIX., 437; Pharm. Centr., 1858, 764; Institut., 1858, 268.
1859	N. de St. Victor and Corvisart.....	Oxalate.....	C. R., XLIX., 368; Institut., 1859, 287; Ann. Ch. Pharm., CXIII., 112; Dingl. J., CLVI., 38; Jahresb., 1859, 33.
1859	Corvisart.....	.....	Jahresb., 1859, 33; Bull. Soc. Chim., 1862, 62.
1860	De Luynes.....	Printing.....	Photogr. J., 1860; Polyt. Centr., 1860.
1860	Burnett.....	Actinometry.....	Phil. Mag. [4], XX., 50 and 406.
1860	Wothly.....	Original announcement.	Horn's Photog. J., XVI., 104.
1860	"	U. with Pt Cl ₂	Polyt. Centr., 1860.
1862	Burghess.....	Toning bath.....	Polyt. Centr., 1862, 1590; Am. J. Photog., 1862.

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....	Simpson		Seely's Am. J. Photog., VII., 295.
....	Draper.....		Brit. J. Photog., II., 241.
1865	Wothly.....		Bull. Belge Photog., 1864; Seely's Am. J. Photog., VII., 1865.
....	"	Specification of patent.	Polyt. Centr., 1865, 943; Photog. Archives, 1865.
1865	Liesegang.....	Ammonio citrate.....	Chem. News, 1865, 103; Pharm. Centr., 1865, 1151.
1866	Bolton.....	Oxyfluoride	See page—.
1869	Bolton.....	Historical and general..	Am. J. Sci., 1869, Sept.

MINERALS.*

ABBREVIATIONS.—U., Uraninite; T., Torbernite; A., Autunite. See Dana, Min.

DATE.	AUTHOR.	MINERAL.	REFERENCES.
1727	Brückmann.....	"Schwarz Beckerz"....	Magn. Dei, 204.
1747	Wallerius.....	"Beckblände".....	Wall. Min., 249.
1758	Cronstedt.....	"Swartblende".....	Cr. Min., 198.
1772	De Born.....	"Pechblende".....	Lithophyl. Born., 133.
.....	".....	"Mica viridis cryst.".....	".....
1780	Werner.....	"Grüner Glimmer".....	Ueb. Cronst., 217.
1787	Klaproth.....	"Uranerz".....	Mem. Akad. Berl., 1787, 160.
1789	".....	"Uranit Spath".....	Schr. Ges. N. Berl. IX, 273.
1789	".....	Analysis U.....	Klap. Beitr., II., 221.
1789	Werner.....	"Chalcolith".....	Berg. J., 376.
1789	".....	"Pechblende".....	Berg. J.
1790	Klaproth.....	Analysis U.....	J. de Phys., XXXVI., 248.
1792	Anonymous.....	Analysis U.....	J. de Phys., XLII., 241.
1793	Karsten.....	".....	Ueb. Wern. Verbess., 43.
1800	".....	"Pecherz".....	Karst. Min. Tabell., 56.
1800	Champeaux.....	Uranite.....	Phil. Mag., 1800, 185.
1801	Haüy.....	Urane oxydulé.....	Haüy Traite.
1802	Sage.....	Analysis U.....	Phil. Mag., 1802; J. de Phys., LV., 314.
1802	Ekeberg.....	Found PO ₅ in T.....	Ann. Ch. Phys. [1], XLII., 233.
1803	Ludwig.....	"Uranglimmer".....	Ludwig. Min., I., 55.
1805	Gregor.....	Analysis T.....	Phil. Trans., 1805; Ann. Phil. V., 281.
1808	Vauquelin.....	".....	Ann. Ch. Phys. [1], XLVIII., 277.
1814	Aiken.....	Uranite.....	Mineralog. Manual, 1814.
1817	Werner.....	"Feste Uranokker".....	Wern. Min. Syst., 26; Hoffm. Min., IX., a, 279.
1819	Berzelius.....	"Urankalk".....	N. Syst. Min., 295; Ann. Chim. Phys. [2], XIII., 31.
1820	Jameson.....	"Uranmica".....	Min. Syst., 1820.
1820	Breithaupt.....	"Uranphyllit".....	Charak. d. Min. Syst.
1821	John.....	"Uranvitriol".....	Chem. Unters., V., 254.
.....	".....	"Zippeite".....	Schweigg. J., XXXII., 245.
1822	Pfaff.....	Analysis U.....	Schweigg. J., XXXV., 326.
1822	Berzelius.....	Hydrate.....	Ann. Ch. Phys. [2], XII., 31; Berz. Jahresb., I., 89.
1823	".....	Analysis T.....	Berz. Jahresb., 1823, 137.
.....	".....	Analysis A.....	Pogg. Ann., I., 374; Schweigg. J., XLIV., 29.
1823	Phillips.....	Analysis T.....	Ann. Phil. [2], V., 57; Am. J. Sci. [1], VII., 380; Schweigg. J., XLIV., 42.
1823	Langier.....	Analysis A.....	Ann. Ch. Phys. [2], XXIV., 239.

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DATE.	AUTHOR.	MINERAL.	REFERENCES.
....	Freiesleben.....	"Lichtes Uranpecherz"	Beitr. Min. Kennt. Sachs., 187.
1824	Zippe.....	"Uranblüthe".....	Verh. Ges. Böhm. Prag., 1824.
1827	Zippe.....	"....."	Kastner's Arch., XII., 252; Berz. Jahreshb., VIII., 198.
1830	Haidinger.....	"Johannite".....	Abh. Böhm. Ges. Prag., 1830; Edinb. J. Sci. N. S., III., 306; Berz. Jahreshb., XI., 208.
1832	Breithaupt.....	"U. Gummierz".....	Charak. Min. Syst., 218.
1833	Kersten.....	"Gummite".....	Pogg. Ann., XXVI., 492; Schweigg. J., LXVI., 18; Ann. Ch. Pharm., VIII., 285.
1834	Kersten.....	Uranpecherz.....	Pogg. Ann., XXVI., 491; Berz. Jahreshb., XIII., 165.
1836	Gerhardt.....	"Uranpecherz".....	J. pr. Ch., IV., 54.
1837	Breithaupt.....	"Uranerz".....	J. pr. Ch., XII., 184.
1841	"....."	"Uranochalcite".....	Breit. Handb. Min., 173.
1843	Ebelmen.....	Analysis U.....	Ann. d. M. [4], IV., 400; Ann. Ch. Phys. [3], VIII., 498; Berz. Jahreshb., XXIV., 304.
1844	Rammelsberg.....	Analysis U.....	Pogg. Ann., LIX., 35; Berz. Jahreshb., XXIV., 304.
1845	Teschemacher.....	.....	Am. J. Sci. [1], XLVIII., 395.
....	Shepard.....	.....	Am. J. Sci. [1], XLVIII., 395.
1845	Haidinger.....	"Uranin".....	Handb. Best. Min., 549.
....	"....."	"Zippeite".....	"....." 510.
1847	Breithaupt.....	"Schwer Uranerz".....	Handb., 1847, 803.
....	"....."	"Urangummi".....	"....."
....	"....."	"U. Pittinerz".....	"....."
1848	Th. Scheerer.....	Analysis U.....	Pogg. Ann., LXXII., 570; N. Jen. Lit. Ztg. 1848, 55.
1848	Werther.....	Uranit.....	J. pr. Ch., XLIII., 332; Jahreshb., 1848, 1218.
1848	Smith.....	"Medjidite".....	Am. J. Sci. [2], V., 337; XL, 259; Ann. Ch. Pharm., LXVI., 254.
1848	Le Conte.....	"Coracite".....	Am. J. Sci. [2], III., 173; Jahreshb. 1848, 1167; 1853, 642.
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1850	Whitney.....	Coracite.....	Am. J. Sci. [2], VII., 434; J. pr. Ch., LI., 127; Phil. Mag. [3], XXXVII., 153.
1852	Brookes & Miller.....		B. & M. Min., 1852, 517.
1852	Haidinger.....	"Eliasite".....	Jahrb. G. Reichs., IV., 124.
1852	Vogl.....	"Liebigite".....	Jahrb. G. Reichs., IV., 221.

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1853	Chapman.....	"Uranatennite".....	Chap. Pract. Min., 148.
1853	Ragsky.....	"Pittnerz".....	Pogg. Ann. Ergänz., IV., 348.
1854	Dauber.....	Basic sulphate.....	Pogg. Ann., XCH., 251.
1857	Vogl.....	Basic sulphate.....	Min. Joach., 1857.
1857	Lindacker.....	.....	Am. J. Sci. [2], XXV., 414; Min. Joach., 1857, 95 & 119; Jahresb., 1857, 694.
1857	Descloizeaux.....	.....	Ann. d. M., XIV., 377.
1857	Genth.....	.....	Am. J. Sci. [2], XXIII., 421; J. pr. Ch., LXXIII., 206; Jahresb., 1857, 663.
1859	Hermann.....	"Uranoniobit".....	J. pr. Ch., LXXVI., 326; Bull. Soc. Nat. Moscou, 1859; Jahresb., 1859, 798.
1859	Hermann.....	"Pittnerz".....	Jahresb., 1859, 798.
1859	Ordway.....	Basic sulphate.....	Am. J. Sci. [2], XXVI., 197; J. pr. Ch., LXXVI., 23.
1860	Theyer.....	Analysis U.....	Ramm. Handb., 1860, 175.
1861	Pisani.....	Analysis A.....	C. R., LII., 817; Jahresb., 1861, 1030; Rep. Chim. Pure, III., 222; J. pr. Ch., LXXXV.; Jahrb. Min., 1862, 601.
1865	Breithaupt.....	{ "Cupouranit"..... } { "Calcouranit"..... }	Berg. u. Hüttenm. Ztg., XXIV., 302.
1865	Church.....	Analysis T.....	Chem. News, XII., 183; Jahresb., 1865, 911.

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Berzelius' Lehrbuch; Gmelin's Handbuch; Graham-Otto's Lehrbuch; Pelouze et Frémy; Liebig & Wöhler's Handwörterbuch; Watt's Dictionary; Dana's Mineralogy; Rammelsberg's Mineralchemie; Rose's Chimie Analytique; Fresenius' Analysis; Muspratt's Chemistry, Bruno Kerl's edition.

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THE BOOK

OF THE

BALANCE OF WISDOM.

AN ESSAY ON DETERMINATIONS OF SPECIFIC
GRAVITY BY THE ARABIANS OF
THE XIITH CENTURY.

READ BEFORE THE N. Y. ACADEMY OF SCIENCES,
MAY 29TH, 1876,

BY

H. CARRINGTON BOLTON, PH.D.

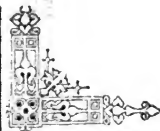
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1879. May 13

Gift of

Prof. J. B. Child

NOTES ON THE EARLY LITERATURE OF CHEMISTRY.

BY H. CARRINGTON BOLTON, PH.D.

VII.

THE BOOK OF THE BALANCE OF WISDOM.

*Read before the New York Academy of Sciences May
29, 1876.*

So rapid are the strides made by science in this progressive age, and so boundless is its range, that those who view its career from without find great difficulty in following its diverse and intricate pathways, while those who have secured a footing within the mysterious domain and are free to journey on the same road are often quite unable to keep pace with its fleet movements and would fain retire from the unequal contest. It is not surprising, then, that those actually contributing to the advancement of science, pressing eagerly upward and onward, should neglect to look back upon the labors of those who precede them, and should sometimes lose sight of the obligations which science owes to forgotten generations.

Could the wisdom of the world concealed in the silent unwritten history of past ages be divulged by a miracle of revelation, how startling and interesting would be the wonderful disclosure! Imagination fails to conceive of the possible social and scientific status of the present era, had the named and the unnamed "lost arts" been preserved through all time, and had the experience of the human race been uninterruptedly handed down to the existing generation.

The legitimate feeling of exultation and satisfaction enjoyed by oriental scholars when years of painstaking

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research amid the musty records of the past are at length rewarded by a literary and historical discovery of importance, seems to us comparable to the pleasurable excitement experienced by the scientists whose investigations of nature are crowned by the determination of a new species, or the establishment of a new law. In this respect, the Egyptologist and the Naturalist, the student of ancient history and the student of modern chemistry, have a common purpose, each in his own sphere seeking the truth.

Original investigations in the field of history are, however, vouchsafed only to those profound linguists whose erudition and skill in deciphering semi-obiterated cryptographs have been the fruit of a lifetime's laborious study; and these absorbed in their study of the ancient, too often neglect to compare the wisdom of early times with the progress of modern scientific truths, and fail to appreciate the points most valuable to the student of science. Hence the history of science yet remains to be written.

This suggestion may be met with references to the works of the savans who, especially in the preceding century, devoted much to the elaboration of historical treatises in their several departments of science; but these are few in number, and as we believe merely sketch the outlines, the details of which will yet be supplied by some mighty genius at once a linguist, an archæologist and a scientist.

Meanwhile, in default of the erudition which alone allows of critical examination of monumental inscriptions, papyri, and original manuscripts, the humble searcher after knowledge must be content to study available translations, notes, and criticisms provided by oriental scholars, and to bring into prominence such materials as his imperfect powers can command.

Bearing in mind the great obligations which the exact sciences owe to the Arabian philosophers of the middle ages, it is not surprising that such of their

works as are made available by the translations of linguists, afford abundant and rich sources of information to the student of the History of Science. The work named at the beginning of this article forms a remarkable contribution to the early history of the determination of specific gravities. This "Book of the Balance of Wisdom" is an Arabic treatise on the water-balance, written in the twelfth century, for an account of which the historian of science is indebted to the chevalier N. Khanikoff, sometime Russian Consul General at Tabriz, an important city of northern Persia. Mr. Khanikoff having obtained access, in some manner not explained, to a manuscript copy of the Arabic work, translated into the French language copious extracts, and prepared an analysis of its contents; these data, together with a transcript of the original Arabic version, he communicated to the American Oriental Society. The Society's Committee of Publication, in preparing the Russian Consul's work for their Journal, translated his notes into English, retranslated the Arabic extracts, and added their own valuable comments. The completed article is found in the sixth volume of the Journal of the American Oriental Society, pp. 1 to 128, published in 1859.

The Book of the Balance of Wisdom treats exclusively of the balance and of the results attainable by this instrument which has given to modern science so many beautiful discoveries. Its exposition of the principles of the centres of gravity, of researches into the specific gravity of metals, precious stones and liquids, shows these Orientals to have attained to experimentation, a step in the progressive knowledge of physical truths entirely unknown to the ancients. Before offering such citations from this work as may seem necessary to establish this proposition, we will endeavor to answer two questions which naturally suggest themselves to our readers. What is the date of the original manuscript, and who was its Author?

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most happily both queries admit of satisfactory replies, based on internal evidence.

The dedication of the work proves it to have been composed at the court of the Saljuke Sultan Sanjar who reigned over a large part of the ancient Caliphate of Bagdad from A.D. 1117 to 1157. In this introduction, the author appeals to this potentate in the following fulsome expressions of homage characteristic of the Orientals:

"Most magnificent Sultan, the exalted Shah of Shahs, the king of subject nations, the chief of the Sultans of the world, the Sultan of God's earth . . . the shelter of Islamism and of Muslims, the arm of victorious power . . . Prince of Believers—may God perpetuate his reign and double his power! For his felicity is the illuminating sun of the world, and his justice its vivifying breath."

And immediately following this passage, occurs mention of the date:

"I sought assistance from his beams of light irradiating all quarters of the world, and was thereby guided to the extent of my power of accomplishment in this work, and composed a Book on the Balance of Wisdom for his high treasury, during the months of the year 515 of the Hegira of our Elect Prophet Mohammed—may the benedictions of God rest upon him and his family, and may he have peace!"

This proves the treatise to have been written in the years 1121-1122 A.D. At this period of the world's history we find Arab philosophers cultivating literature and science, while the rest of Europe was just emerging from intellectual darkness. The religious world had scarce recovered from the intense excitement aroused by Peter the Hermit and his followers, who led the tumultuous rabble 600,000 strong towards the Holy City; and priests, knights and peasants were preparing with frantic zeal for a Second Crusade. Abélard and Héloïse were names which afforded endless discussions in the cloister and on the hearth. Science was at a low ebb, a century elapsed before

Albertus Magnus and Roger Bacon exerted their influence ; and scholastic philosophy, attaining its loftiest height, swayed the intellects of the age.

The authorship of the Book of the Balance of Wisdom is easily determined by the fortunate circumstance that the author names himself several times, "but in so modest a manner as scarcely to attract attention ; instead of heralding himself at once, in his first words, after the usual expressions of religious faith, as Arab authors are wont to do, he begins his treatise by discoursing on the general idea of the balance" and then simply remarks : "*Says al-Khazini, after speaking of the balance in general,*" and proceeds to enumerate the advantages of the balance which he is about to describe. Two other passages in the extracts furnished by Mr. Khanikoff satisfy the Oriental scholars who have examined them that the author is this self-named al-Khazini.

Attempts to identify al-Khazini with individuals of historical fame have given rise to differences of opinion, but the weight of evidence is in favor of regarding him as the same with Alhazen the Arab optician and physiologist.

Alhazen seems to have been a native of Persia and to have resided in Spain and Egypt, but of his biography little is known. He is especially distinguished for his demonstration of the theory of vision, showing that the rays of light are reflected from external objects to the eye and do not issue forth from the eye to impinge on external things, as up to his time had been taught.

This explanation, moreover, was not based on mere hypothesis, but was the result of anatomical investigations as well as of mathematical discussions.

Alhazen also explained the astronomical refraction of light, its dependence on the variation of the density of the media traversed, and its influence in producing the phenomenon of twilight. In the discussion of all

these problems he evinced true scientific greatness. He favored the theory of the progressive development of animal forms, anticipating a doctrine but newly obtaining acceptance. Dr. J. W. Draper,* who has been our guide in this connection, says of Alhazen: "Though more than seven centuries part him from our times, the physiologists of this age may accept him as their compeer."

The name al-Khazini signifies "related to the treasurer," which accords with his statement that the work was composed for the royal treasury.

The Book of the Balance of Wisdom begins with a dedication to God "the compassionate, the merciful," and a pious statement of the author's religious faith. An introduction, divided into eight sections, then follows; in the first section, the advantages and uses of the Balance are enumerated in this language:

"These advantages are: 1, exactness in weighing; this balance shows variations to the extent of a mithkal,† or of a grain, although the entire weight is a thousand mithkals, provided the maker has a delicate hand, attends to the minute details of the mechanism, and understands it; 2, that it distinguishes pure metal from its counterfeit, each being recognized by itself without any refining; 3, that it leads to a knowledge of the constituents of a metallic body without separation one from another.....; 4, that it shows the superiority in weight of one of two metals over the other in water, when their weight in air is the same, and reversely.....; 5, that it makes the substance of the thing weighed to be known by its weight.....; 6.....; 7, the gain above all others——that it enables one to know what is a genuine precious stone, such as a hyacinth, or ruby, or emerald, or fine pearl; for it truly discriminates

* Hist. Int. Devel. Europe, page 360.

† We cannot here undertake to discuss the ancient Arabic system of weights, but merely state that while authorities differ, Mr. Khanikoff, after a careful examination and comparison of modern and ancient standards of weight in Georgia, Daghistan and elsewhere, where Arabic customs have suffered little change, assigns to the mithkal the value of 4.5 grammes. The mithkal, according to Abu-r-Raihan (quoted below) equals 6 danika; 1 danik=4 tassujs; 1 tassuj=4 grains; and 1 grain =4 barley-corns.

between these and their imitations or similitudes in color, made to deceive."

Then follows the theory of the water balance; and in the fourth section some account of its early history and the well-known narrative of King Hiero's crown.

"It is said that the [Greek] philosophers were first led to think of setting up this balance and moved thereto by the book of Menelaus * addressed to Domitian, in which he says: 'O King, there was brought one day to Hiero, King of Sicily, a crown of great price, presented to him on the part of several provinces, which was strongly made and of solid workmanship. Now it occurred to Hiero that this crown was not of pure gold, but alloyed with some silver; so he inquired into the matter of the crown, and clearly made out that it was composed of gold and silver together. He therefore wished to ascertain the proportion of each metal contained in it, while at the same time, he was averse to breaking the crown on account of its solid workmanship. So he questioned the geometricians and mechanicians on the subject, but no one sufficiently skilled was found among them, except Archimedes the geometrician, one of the courtiers of Hiero. Accordingly he devised a piece of mechanism which, by delicate contrivance, enabled him to inform King Hiero how much gold and how much silver was in the crown, while yet it retained its form. This was before the time of Alexander. Afterwards Menelaus [himself] thought about the water-balance and brought out certain universal arithmetical methods to be applied to it; and there exists a treatise by him on the subject. It was then four hundred years after Alexander."

Al-Khazini takes pains in this sketch of the early history of specific gravity, to establish dates by reference to cotemporaneous individuals, but his chronology is evidently at fault. The Hiero alluded to is Hiero II., who died 216 B.C., while Alexander the Great lived more than a century earlier (356 B.C.—323 B.C.)

This Arabic version of the anecdote of Hiero's

* A celebrated mathematician who lived in the reign of Trojan, 96—117 A.D., and author of a treatise on Spherical Geometry.

crown lacks the piquancy and interest of the narrative as originally given by Vitruvius, and is moreover not an accurate transcription; the words "devised a piece of mechanism" convey the impression that Archimedes constructed some peculiar form of apparatus with which to solve the problem. Indeed this story, familiar as it is, is not unfrequently erroneously related, even as al-Khazini himself has done, and compilers of text-books of natural philosophy, content to copy from each other instead of seeking the original sources, transmit the errors of detail.

These reflections are in part suggested by a singular construction given to the narrative in a recent and really excellent text-book on the History of Natural Science, in which the authoress commits the remarkable anachronism of representing (in a woodcut) the crown and the metallic masses suspended in water from *spring-balances* of modern appearance and construction.

To dispel any lingering ideas of this character we here revive the passage in Vitruvius,* "*De Architectura*," the original source of the narrative, and in which it appears that the "greatest geometer of antiquity" arrived at his results by a comparison of unequal volumes of water obtained by displacement, and not by direct weighings in that liquid.

"BOOK IX. CHAPTER 3. *Of the method of detecting silver when mixed with gold.*"

"Though Archimedes discovered many curious matters which evince great intelligence, that which I am about to mention is the most extraordinary. Hiero, when he obtained the royal power in Syracuse, having, on the fortunate turn of his affairs, decreed a votive crown of gold to be placed in a certain temple to the immortal gods, commanded it to be made of great

* Marcus Vitruvius Pollio, a distinguished Roman architect and author, served as military engineer under Julius Caesar in Africa, B.C. 46. His work, "*De Architectura*," (written in his old age), comprising ten books, is the only ancient treatise on the subject extant. Of Vitruvius' biography very little is known.

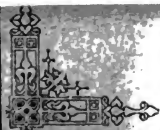
value, and assigned an appropriate weight of gold to the manufacturer. He, in due time, presented the work to the King, beautifully wrought, and the weight appeared to correspond with that of the gold which had been assigned for it. But a report having been circulated that some of the gold had been abstracted, and that the deficiency thus caused had been supplied with silver, Hiero was indignant at the fraud, and unacquainted with the method by which the theft might be detected, requested Archimedes would undertake to give it his attention.

"Charged with this commission, he, by chance, went to a bath, and being in the vessel, perceived that as his body became immersed, the water ran out of the vessel. Whence, catching at the method to be adopted for the solution of the proposition, he immediately followed it up, leaped out of the vessel in joy, and returning home naked, cried out with a loud voice that he had found that of which he was in search, for, he continued exclaiming in Greek, *εὕρηκα* (I have found it out).

"After this he is said to have taken two masses, each of a weight equal to that of the crown, one of them of gold and the other of silver. Having prepared them he filled a large vase with water up to the brim, wherein he placed the mass of silver, which caused as much water to run out as was equal to the bulk thereof. The mass being then taken out, he poured in by measure as much water as was required to fill the vase once more to the brim. By these means he found what quantity of water was equal to a certain weight of silver. He then placed the mass of gold in the vessel, and on taking it out, found that the water which ran over was lessened, because the magnitude of the gold mass was smaller than that containing the same weight of silver.

"After again filling the vase by measure, he put the crown itself in, and discovered that more water ran over than with the mass of gold, that was equal to it in weight; and thus from the superfluous quantity of water carried over the brim by the immersion of the crown, more than that displaced by the mass, he found by calculation, the quantity of silver mixed with the gold and made manifest the fraud of the manufacturer." *

* The Architecture of Marcus Vitruvius Pollio. in ten books. Translated from the Latin by Joseph Gwilt, London, 1826, pp. 264, 265.



Continuing the sketch of the history of the water-balance given by al-Khazini in the fourth section of the Introduction, we find references to several Arabian philosophers, among them the celebrated physician Avicenna (Ibn Sina) who "distinguished [the components of] a compound scientifically and exactly," and Abu-r-Raihan "who took observations on the relations of [different] metallic bodies and precious stones, one to another, as indicated by this balance."

Al-Khazini also states that the instrument in question was called "the Physical Balance" by Mohammed Bin Zakariya of Rai, and it was named "the Balance of Wisdom," by the "eminent teacher Abu-Hatim al-Muzaffar Bin Ismail of Isfazar."

Abu-r-Raihan alluded to above is often quoted by al-Khazini and deserves our attention. He was a distinguished Arabian astronomer born about 970, and died 1038 A.D. He was a member of the Society of Savans founded in the capital of Kharizm, and of which the eminent physician Avicenna was a shining light. He was the author of a number of works on astronomy, cosmography and physics, one of which entitled "The Book of the Best Things for the Knowledge of Mineral Substances," and contained in the *Ayin-Akbari*, or Institutes of the Emperor Akbar, treats of the specific gravity of bodies and of hydrostatic methods for determining them. It is this work to which al-Khazini refers. A review of Abu-r-Raihan's treatise has been published by M. J. J. Clément-Mullet, under the title, "*Recherches sur l'Histoire Naturelle et la Physique chez les Arabes.*" * Since this Arabic manuscript is probably the most ancient work extant which systematically treats of specific gravities, we make another digression and give a brief synopsis of its contents.

It contains theoretical explanations of the origin

* *Journal Asiatique*. Serie v., Vol. xl., p. 379.

and formation of mineral bodies founded on the views of the Greeks, and particularly on those of Aristotle. According to these views, the variety of the weights of bodies depends upon the dry and the moist exhalation from them; air and water are the elements of these vapors, air giving the lightness and water the heaviness. The author then proceeds to describe methods for determining the specific gravity of bodies in the following words:

"Scientific men determine by means of water the measure of these differences in weights. They prepare a vessel filled with water in which they introduce 100 mithkals of each of the metals; the quantity of water thrown out by each gives the difference in volume and weight, that one which displaces the largest bulk of water has consequently the largest volume but the least density, and that one which displaces the least water is the heaviest."

Abu-r-Raihan gives in tabular form the specific gravity of nineteen substances, nine of which are minerals and nine are stones. In the following table we annex the values assigned by modern authorities, showing the remarkable accuracy, in most instances, of the early determinations.

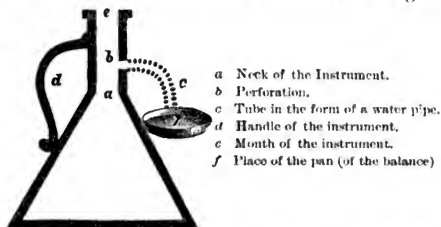
TABLE OF SPECIFIC GRAVITIES.

	<i>Abu-r-Raihan.</i>	<i>Modern Authorities.</i>
Gold.....	19.05	19.30
Mercury.....	13.58	13.568
Lead.....	11.33	11.346
Silver.....	10.35	10.52
Bronze.....	8.82	8.05 to 8.95
Copper.....	8.70	8.78
Brass.....	8.57	8.58
Iron.....	7.74	7.79
Tin.....	7.31	7.29
Sapphire.....	3.97	3.09
Oriental Ruby.....	3.58	3.00
Ruby.....	3.85	3.52
Emerald.....	2.75	2.73
Pearl.....	2.69	2.75
Lapis Lazuli.....	2.60	2.90
Cornelian.....	2.56	2.61
Amber (?).....	2.53	1.08 (?)
Rock crystal.....	2.50	2.58

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In the third lecture of the Book of the Balance of Wisdom al-Khazini describes a form of specific gravity flask which he calls the "conical instrument of Abu-r-Raihan" and to whom he apparently ascribes the invention. A mere inspection of the accompanying cut, a fac-simile of that in the original manuscript, together with the explanations (also from the original), suffices to show its nature and the method of using it.



The author remarks that "the instrument is very difficult to manage, since very often the water remains suspended in the lateral tube, dropping from it little by little into the scale of the balance." This passage shows that Abu-r-Raihan had noticed capillary attraction; it is also certain that he understood that the size of the neck of the instrument affected the delicacy of the determinations, for he says he would have it "made narrower than the little finger but for the difficulty of removing through a smaller tube the bodies immersed in the water."

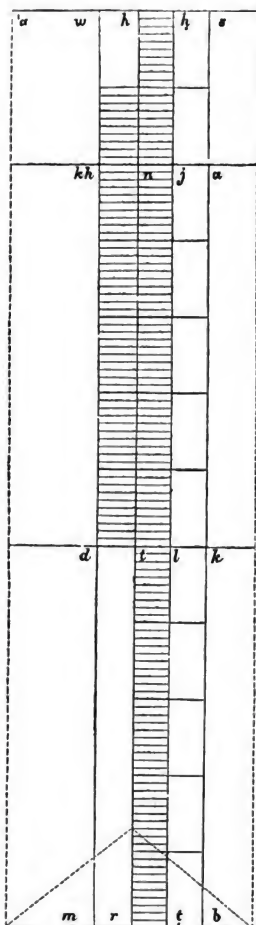
Al-Khazini's work is made up of eight lectures, each lecture includes several chapters and each chapter has several sections; to give the table of contents entire would undesirably lengthen this article, and we prefer to quote Al-Khazini's own summary of his treatise as contained in the sixth section of the introduction.

"I have divided the book into three parts: 1. Général and fundamental topics, such as heaviness and lightness; centres of gravity; the proportion of the submergence of ships in water; diversity of the causes of weight; mechanism of the balance and the steelyard; mode of weighing with it in air and in liquids; the instrument for measuring liquids, in order to ascertain which is the lighter and which is the heavier of two, without resort to counterpoises; knowledge of the relations between different metals and precious stones in respect to [given] volume; sayings of ancient and modern philosophers with regard to the water balance and their intimations on the subject. This part includes four lectures of the book in their order. II. Mechanism of the balance of wisdom; trial of it; fixing upon it of [the points indicating] the specific gravities of metals and precious stones; adoption of counterpoises suited to it; application of it to the verification of metals and distinguishing of one from another [in a compound], without melting or refining, in a manner applicable to all balances; recognition of precious stones and distinction of the genuine from their imitations or similitudes in color. There are here added chapters on exchange and the mint, in connection with the mode of proceeding, in general, as to things saleable and legal tenders. This part embraces three lectures. III. Novelties and elegant contrivances in the way of balances such as: the balance for weighing dirhams and dinars without resort to counterpoises; the balance for leveling the earth to the plane of the horizon; the balance known as the 'even balance' which weighs from a grain to a thousand dirhams or dinars by means of three pomegranate counterpoises; and the hour-balance, which makes known the passing hours, whether of the night or of the day, and their fractions in minutes and seconds, and the exact correspondence therewith of the ascendant star and fractions of a degree. This part is in one lecture."

In the seventh chapter, which treats of the "Mechanism of the Instrument for measuring Liquids . . . and Application of it according to the philosopher Pappus the Greek," we find a description of a hydrometer.

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"The length of this instrument, which is cylindrical in shape, measures half a hand-cubit; and the breadth is equal to that of two fingers, or less. It is made of brass, is hollow, not solid, and the lighter particles of brass are carefully turned off by the lathe. It has two bases, at its two ends, resembling two light drum-skins, each fitted to the end, carefully, with the most exact workmanship; and on the inner plane of one of the two bases is a piece of tin, carefully fitted to that plane by the lathe, shaped like a funnel, the base of which is the drum-skin itself. The instrument being thus made, when put into liquid in a reservoir or vessel, it stands upon it in an erect position and does not incline anyway."

The author then describes at length, the manner of graduating the instrument, the decimal system being employed throughout. He remarks that the weight of the funnel shaped piece of tin must be varied according to the den-

sity of the water assumed as a standard. Tables of the specific gravities corresponding to the marks on the instrument accompany the detailed account of its application.

The annexed figure of the hydrometer of Pappus (page 16) does not give a very clear idea of the instrument, and is intended to show chiefly the manner of constructing and graduating it; the details given in the manuscript are so minute, however, that it is evident Pappus' instrument resembled closely that of Gay-Lussac. It was, however, provided with two scales, one with its numbers increasing upwards to indicate the volume submerged in liquids of different density; the other with its numbers increasing downwards, to show the specific gravities corresponding to those submerged volumes.

The above-mentioned Pappus was an eminent Greek geometer of Alexandria, who flourished about 380 or 400 A.D. Consequently he was a cotemporary of Synesius of Cyrene (378-480 A.D.), in one of whose letters occurs what is ordinarily regarded as the first recorded mention of the hydrometer. It is certainly most interesting to find that al-Khazini's description of Pappus' instrument corresponds very closely with the statements of Synesius, a coincidence not observed by previous writers.

Synesius, "the good bishop of Ptolemais," writing to his instructress,* the fair pagan philosopher and mathematician, the ill-fated Hypatia, and being desirous of trying the wines † he is using, says:

"My health is so delicate that I need a *hydroscope*, and I beg you to have one made for me of copper. It is a tube cylindrical in shape and of the form and size of a pipe: on its length it bears a straight line crossed by small lines, by means of which we determine the weight of waters. One end is terminated by a cone,

* Not in a letter of Hypatia to Synesius, as Hoefer has it in his *Hist. Physique*, Paris 1872, 12mo.

† Draper, *Hist. Int. Devel. Europe*.

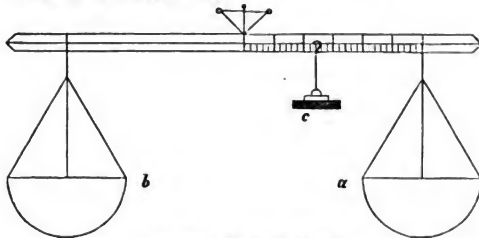
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arranged in such a manner that the tube and the cone have the same base. This instrument is called *barylion*. If you place it in water, point downwards, it stands erect and the divisions that cross the vertical line can be easily counted, and by this means the density of water is determined.*

Hoefer, the French Historian of Chemistry, in relating this statement remarks that none of the commentators of the Letters of Synesius were able to explain the nature of this instrument until the mathematician Fermat, in answer to Castelli's request, communicated his view, correctly apprehending the principles and uses of the instrument described. This was in 1628, and now we learn that the Arabian philosophers five centuries earlier were perfectly familiar with the identical instrument mentioned by Synesius.

Al-Khazini describes several forms of balances at great length, giving details of construction and employment. One of these balances he ascribes to Archimedes; and he professes to quote the particulars respecting it from Menelaus, without however giving the title of the latter's work.



BALANCE OF ARCHIMEDES.

- a. Bowl for gold .
- b. Bowl for silver.
- c. Movable weight.

Another balance described by our author is that of Muhammed Bin Zakariya of Rai; it differs from that

* Synesius Opera, Epist. XV. Lutetia, 1612, 4to, p. 174.

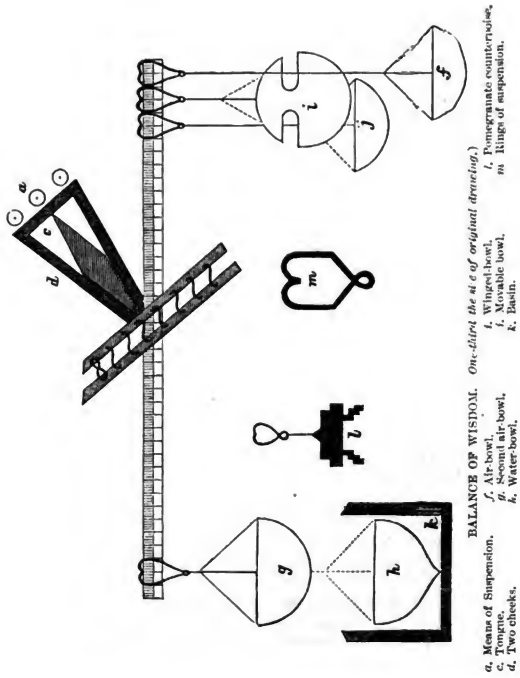
of Archimedes by the introduction of the needle, called by the Arabs the "tongue," and by the substitution of a movable suspended bowl for the movable weight.

Finally, in the fifth lecture, he gives a minute description of the Balance of Wisdom according to Abu-Hatim al-Muzaffar Bin Ismail of Isfazar. "He begins by remarking, that the balance being an instrument of precision, like astronomical instruments such as the astrolabe and the zijassafai, its whole workmanship should be carefully attended to, He next describes the beam, the front piece, the two 'cheeks' between which the 'tongue' moves, and the tongue itself." He gives the length of the beam as four bazaar cubits (two meters) and remarks that "length of the beam influences the sensibility of the instrument;" it is constructed of iron or bronze. The balance is provided with five bowls or pans, made of very thin plates of bronze, three of which have the form of hemispheres (see engraving, page 20), one of which is spherical and the remaining one, destined to be plunged into water, is finished with a conical bottom. Two of these bowls bore the name of the "aerial" and were permanently attached to the beam; another pan was movable on the right arm of the beam; and the bowl intended to be immersed in water was fastened underneath the aerial bowl of the left arm; this bowl bore the name of the "aquatic" and the spherical bowl was named the "winged."

We cannot here enter upon a more detailed examination of this portion of al-Khazini's treatise; suffice it to say, he speaks of the mode of adjusting the balance and of its application to the examination of metals and of precious stones. Al-Khazini distinctly states that in taking the specific gravity of bodies he employed "a determined sort of water similar in density to the water of the Jaihun of Khuwarazm," and further that "we made all our comparisons in one

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single corner of the earth, namely in Jurjaniyah [a city] of Khuwarazm and early in the autumnal season of the year." The "Jaihun" is the modern river Oxus, and "Khuwarazm" corresponds to the modern province of Khiva.

The editor, Mr. Khanikoff, calls special attention to the following passages, which he considers the most remarkable in the whole treatise:

"When a heavy body of whatever substance is transferred from a rarer to a denser air it becomes lighter in weight, from a denser to a rarer air it becomes heavier." (Lect. I. Chap. v. § 1.)

"Air-weight does not apparently vary, although there is actual variation, owing to difference of atmospheres. As regards its water-weight, a body visibly changes, according to the difference between waters of [different] regions, wells and reservoirs, in respect to rarity and density, together with the incidental difference due to the variety of seasons and uses. So then the water of some determined region and known city is selected, and we observe upon the water weight of the body, noting exactly what it is, relatively to the weight of one hundred mithkals; and we refer [all] operations to that [result as a standard,] and keep it in mind against the time when we are called upon to perform them, if the Supreme God so wills. In winter one must operate with tepid, not very cold water, on account of the inspissation and opposition to gravity of the latter, in consequence of which the water-weight of the body [weighed in it] comes out less than it is found to be in summer. This is the reason why the water-bowl settles down when the water has just the right degree of coldness, and is in slow motion, while in case it is hot and moving quickly, or of a lower temperature, yet warmer than it should be, the bowl does not settle down as when the water is tepid. *The temperature of water is plainly indicated, both in winter and summer*; let these particulars therefore be kept in mind." (Lect. V. Chap. vi. § 5.)

An examination of these extracts compels a belief that the Arabian philosophers of the twelfth century knew the air to have weight, though they never applied the means they had discovered of measuring

it. The sentence in italics leads to the conjecture that they also had some means of determining the temperature of water; possibly a form of *ærometer* was the instrument employed, and they were thus enabled to recognize the fact that the density of water increases in proportion to its coldness.

Al-Khazini's work contains several tables of the specific gravities of substances determined either by the Balance of Wisdom or by the hydrometer of Pappus. In these tables are enumerated fifty substances, nine of which are metals, ten precious stones, thirteen materials of which models were made, and eighteen liquids. The smallness of the list is not surprising, for most of the substances contained in modern lists of specific gravities were entirely unknown to the Arabians; the exactness of the results obtained is marvellous, when we take into consideration the coarseness of their means of graduating instruments and the backward state of the mechanical arts at that period.

The first table comprises the specific gravities of seven metals and two alloys; the results interpreted into our system, together with the values assigned by modern authorities* are found below. For sake of comparison, we also annex the figures obtained by Abu-r-Raihan, from whom it is believed al-Khazini quotes; the slight discrepancies are largely due to different methods of calculation adopted by Clément-Mullet and Khanikoff.

AL-KHAZINI'S FIRST TABLE OF SPECIFIC GRAVITIES.

Substances.	Al-Khazini.	Abu-r-Raihan.	Modern Authorities.
Gold [cast].....	19.05.....	19.05.....	19.30
Mercury.....	13.56.....	13.58.....	13.59
Lead.....	11.32.....	11.33.....	11.34
Silver.....	10.30.....	10.35.....	10.52
Bronze.....	8.82.....	8.82....	8.05 to 8.95

* Cf. Prof. F. W. Clarke's *Tables of Specific Gravities, etc.* in *Constants of Nature*, Part I. Smithsonian Miscellaneous Collections, 1873, 8vo.

Copper	8.66.....	<u>8.70</u>	8.78
Brass	8.57.....	<u>8.57</u>	8.58
Iron (forged). 7.74.....		<u>7.74</u>	7.79
Tin	7.32.....	<u>7.31</u>	7.29

It is interesting to learn that the Arabian physicists fully appreciated the necessity of operating on pure materials and the advantages of averaging the results of many determinations.

Thus, al-Khazini says he purified gold by melting it five times, after which it melted with difficulty, solidified rapidly, and left hardly any trace upon the touchstone: and, after ten trials to obtain the weight of the volume of water displaced by different weights of the gold, he found, for a hundred mithkals of gold, weights varying from 5 mithkals 1 danik and 1 tassuj to 5 mithkals 2 daniks; as mean weight he adopts 5 mithkals 1 danik 2 tassuj, which by calculation yields the figures in the preceding table.

Likewise mercury was purified by passing it repeatedly through many folds of linen cloth. In writing of mercury, he remarks that it is not, properly speaking a metal, but it is "the mother of the metals, as sulphur is their father." This view of the nature of mercury was prevalent among Arabian Chemists, and is found in the writings of Geber (or Djafar) who lived four centuries earlier. Geber writes of mercury: "it is also (as some say) the matter of metals with sulphur,"* and he does not place it in the same class with metals which he defines as "extensible under the hammer," a property not possessed by mercury under ordinary conditions.

In this conception of al-Khazini we find moreover the germs of the doctrine of the transmutation of metals, the basis of that alchemical pseudo-science which subsequently acquired such a wonderful influence over the human race. For if metals have

* Geber, *Sum of Perfection*, Book I, Part III. Chap 6.

mercury for a mother and sulphur for a father, they are not simple substances, and if compounds, they are capable of artificial preparation and mutual transformation. This is, however, not the only passage containing allusions to a belief in transmutation, though no mention occurs of any practical attempts to effect it; the following extract clearly refers to the compound nature of metals.

"When the common people hear from natural philosophers that gold is the most equal of bodies, and the one which has attained to perfection of maturity, at the goal of competition in respect to equilibrium, they firmly believe that it is something which has gradually come to that perfection by passing through the forms of all [other metallic] bodies, so that its gold nature was originally lead, afterwards became tin, then brass, then silver, and finally reached the perfection of gold."

Writing of the precious metals, al-Khazini discourses in a philosophical spirit on their universal appreciation, in the following language:

"Men prize these metals," says Abu-r-Railhan, 'only because under the action of fire they admit of being made into conveniences for them, such as vessels more durable than others, instruments of agriculture, weapons of war, and other things which no one can dispense with, who is set to possess himself of the good things of life and is desirous of the adornments of wealth.' But if besides the rarity of the occurrence of gold, its durability and the little appearance of moisture upon it, whether moisture of water or humidity of the earth, or of its being cracked or calcined by any fire, and consumed together; with its ready yielding to the stamp, which prevents counterfeiters from passing off something else for it, and lastly the beauty of its aspect—if there is not [besides all these characteristics] some inexplicable peculiarity pertaining to gold, why is the little infant delighted with it, and why does he stretch himself out from his bed in order to seize upon it? And why is the young child lured thereby to cease from weeping, although he knows no value that it has, nor by it supplies any want? And why do all people in the world make it the ground of being at

peace one with another, not drawing their swords to fight, though at the sacrifice of the powers of body and soul, of family connections, children, ground possessions, and everything, with even a superfluity of renunciation for the sake of acquiring that; and yet are ever longing for the third stream* to stuff their bellies with the dust?"

This passage is a sample of the simplicity of much of the Book of the Balance of Wisdom; and, occurring in the midst of the purely scientific demonstrations and data, is peculiarly refreshing; the author's testimony to that inexplicable peculiarity of gold which renders it the special object of avarice, leads us to conjecture that had he lived in modern times he would have proved a warm champion of "hard money" doctrines.

The second table of specific gravities contains the determinations of various precious stones; it is not possible in every case to identify the stones, and hence some uncertainty obtains with regard to the values:

SUBSTANCES.	SPECIFIC GRAVITIES.	
	Al-Khazini.	Modern Authorities.
Celestial Hyacinth.....	3.96*	4.83
Red Hyacinth.....	3.85†	3.99
[Ruby] of Badakhshan.....	3.58	—
Emerald.....	2.75	2.68 to 2.77
Lapis Lazuli.....	2.69	2.9
Fine Pearl.....	2.60	2.68
Cornelian.....	2.56	2.62
Coral.....	2.56	2.69
Onyx and Crystal.....	2.50	2.63 ‡ to 2.88 §
Pharaoh's glass.....	2.49	2.45 | to 3.44**

Al-Khazini gives detailed accounts of these pre-

* Alluding, say the editors, to the traditional saying of the Arabians: "If the son of Adam were to possess two flowing rivers of gold and silver, doubtless he would desire a third."

• Oriental sapphire.

† Oriental ruby.

‡ Onyx 2.63 to 2.81.

§ Rock crystal 2.63 to 2.88.

| English mirror glass.

** English flint glass.

cious stones, of which we quote a few brief extracts. He says: "Emerald and chrysolite are interchangeable names, whether applied to one and the same thing, or to two things of which one has no real existence," a passage which shows that mineralogical terminology was afflicted with superfluous synonyms at an early day. Of the cornelian he says: "Men have long tired of the cornelian, so that it has ceased to be used as a stone for seal-rings; even for the hands of common people, to say nothing of the great." Of the "fine pearl," he writes: "The pearl is not a stone at all, but only the bone of an animal, and not homogeneous in its parts." "Coral," he writes, "is a plant, though petrified like the Jew's stone and the sea-crab." He is aware that "glass is not the product of a mine, but, on the contrary, kindred to stones, or sand, or alkali," and he states that he has included it in the above list, "because it resembles crystal."

The third table comprises "the materials of models and patterns formed by goldsmiths, and woods of well known trees." Interpreting the Arabic weights as before, we have the following table:

SUBSTANCES.	SPECIFIC GRAVITIES.	
	Al-Khazini.	Modern Authorities.
Clay of Siminjan.....	1.99	clay 1.068 to 2.63
Pure salt.....	2.19	2.068 to 2.17
Saline earth.....	1.11	
Sandarach.....	0.71	1.05 to 1.09
Amber.....	0.85	1.06 to 1.08
Enamel.....	3.93	
Pitch.....	1.04	1.07
Wax.....	0.95	0.96
Ivory.....	1.64	1.82
Ebony.....	1.13	1.18
Pearl shell.....	2.48	2.64
Bakkam wood.....	0.94	1.03
Willow wood.....	0.40	0.58

The last table embraces a number of liquids.

SUBSTANCES.	SPECIFIC GRAVITIES.	
	Al-Khazini.	Modern Authorities.
Sweet water.....	1.	1.
Hot water.....	.958	.959
Ice	.965	.916 to .926
Sea water.....	1.041	1.028 to 1.04
Water of Indian melon.....	1.016	
Salt water [saturated solution].	1.144	1.205
Water of cucumber.....	1.017	
Water of common melon.....	1.030	
Wine vinegar.....	1.027	
Wine.....	1.022	1.013
Oil of sesame.....	.915	.992 to 1.038
Olive oil	.920	.917 to .919
Cow's milk.....	1.110	1.029 to 1.040
Hen's egg.....	1.035	1.09
Honey.....	1.406	1.450
Blood of men in good health..	1.033	1.053
Warm human urine.....	1.018	1.011
Cold human urine.....	1.025	

The temperatures at which the determinations of the "hot water" and "sweet water" were made are not known; the difference of density observed, viz., 0.04166, approximates that between water at 3.9°C. and 100°C., which according to modern physicists is equal to 0.04044.

The high specific gravity of cow's milk is noteworthy and may have led al-Khazini and others into lactometrical controversy.

Besides these contributions to the knowledge of specific gravities, al-Khazini devotes some attention to certain subjects not closely connected with the main theme. In the third lecture he attempts to calculate the quantity of gold which would compose a sphere equal to the globe of the earth, and arrives at a number of mithkals which requires for expression twenty-nine digits.

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In the same lecture he takes up the problem of the chess-board, of which he supposes the squares to be filled with dirhams, each square containing twice the number in the preceeding; he finds the total number of dirhams to be 18,446,744,073,709,551,615. He then applies himself to ascertaining the dimensions of the treasury in which the treasure should be deposited, and finally quotes the lines of an Arabian poet which fix the time in which one might spend this sum at 200,000,000,000,000 years.

In the last lecture he describes the methods of applying the balance to leveling and to the measuring of time—of this portion Mr. Khanikoff gives the following concise exposition :

“The balance level consists of a long lever, to the two ends of which were attached two fine silken cords, turning on an axis fixed at a point a little above its centre of gravity, and suspended between two sight-pieces of wood, graduated. At the moment when the lever became horizontal, the cords were drawn in a horizontal direction, without deranging its equilibrium, and the divisions of the scales of the sight-pieces corresponding to the points where the cords touched them, were noted. For leveling plane surfaces, use was made of a pyramid with an equilateral triangular base, and hollow and open to the light, from the summit of which hung a thread ending with a heavy point. The base of the pyramid thus arranged was applied to the plane which was to be leveled, and carried over this plane in all directions. Wherever the plane ceased to be horizontal the joint deviated from the centre of the base.

“The balance-clock consisted of a long lever suspended similarly to the balance-level. To one of its arms was attached a reservoir of water, which, by means of a small hole perforated on the bottom of it, emptied itself in twenty-four hours. This reservoir, being filled with water, was poised by weights attached to the other arm of the lever, and in proportion as the water flowed from it, the arm bearing it was lifted, the weights on the other arm slid down, and by their distance from the centre of suspension indicated the time which had elapsed.”

Further analysis of the contents of this extraordinary work is incompatible with our reader's patience, and yet many points of interest demand at least a passing notice; these may, however, be embodied in a summary of the principal propositions contained in this treatise, and the recapitulation may serve to justify in some measure this Contribution to the Early History of Chemical Physics.

1. The Book of the Balance of Wisdom shows the Arabian philosophers of the twelfth century to have entertained advanced views regarding attraction. They recognized gravity as a force, and attributed to it a direction towards the centre of the earth; they also knew that it diminishes with the distance, but they erroneously supposed this diminution to be in the direct ratio of the distance and not as its square.

2. They were acquainted with the connection between the weight of the atmosphere and its increasing density, since mention is made of the loss of weight of a body weighed in a denser atmosphere.

3. They understood the theory of centre of gravity, and applied it to the investigation and construction of balance, and steelyards.

4. They made frequent use of the hydrometer, which they inherited from antiquity, and possibly they employed this instrument as a thermometer for distinguishing by variations of density the different temperatures of liquids.

5. They observed the action of capillary attraction.

6. They compiled full and accurate tables of the specific gravities of most of the solids and liquids with which they were acquainted.

7. Their system of philosophy was founded on experiment and observation.

In conclusion, we quote the following appropriate remarks from M. Khanikoff's introduction:

"The history of the sciences presents to us an incontestable fact of deep significance: the rediscov-

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ery in modern times of truths laboriously established of old ; and this fact is of itself enough to indicate the necessity of searching carefully in the scientific heritage of the past after all that it may be able to furnish us for the increase of our actual knowledge ; for a double discovery, necessarily requiring a double effort of human intellect, is an evident waste of that creative force which causes the advance of humanity in the glorious path of civilization."

SCHOOL OF MINES, COLUMBIA COLLEGE,
NEW YORK, MAY, 1876.

GEORGE PROCTOR, F.R.S.E.

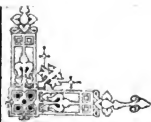
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APPLICATION OF
ORGANIC ACIDS

TO THE

EXAMINATION OF MINERALS.

[First Series]

BY

H. CARRINGTON BOLTON, Ph.D.

REPRINTED FROM THE ANNALS OF THE NEW YORK ACADEMY OF
SCIENCES, VOL. I, 1877.

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APPLICATION OF ORGANIC ACIDS TO THE EXAMINATION OF MINERALS.

By H. CARRINGTON BOLTON, Ph.D.

Read before the New York Academy of Sciences, April 30, 1877.

1. The organic acids have long been used in various operations of chemical analysis, but their direct application to the decomposition of minerals, with a view to the determination of the latter, appears to have been overlooked. Acetic acid finds frequent employment in quantitative analysis; tartaric and citric acids are used to hold ferric and aluminic hydrates in solution in the presence of alkalies, to dissolve antimonie oxide in mineral analysis and in blow-pipe tube reactions,* and in the preparation of Fehling's copper solution; ammonium citrate is used to dissolve so-called "reverted" calcium phosphate, and to separate lead sulphate from the sulphates of the alkaline earths; oxalic acid is used to dissolve sulphide of tin in the separation of this metal from antimony,† in volumetric analysis, in the determination of the metals of the magnesium

* Prof. E. J. Chapman, *Canadian Journal*, Sept., 1865, p. 348.

† Prof. F. W. Clark, *American Journal of Science*, [2] XLIX, 42.

group,* in the valuation of manganese ores, and in many other processes.

The behavior of minerals with the organic acids named has been only casually studied, and in but few instances; T. Sterry Hunt,† following Karsten, has made use of acetic acid in the proximate analysis of mixtures of calcite, dolomite, and magnesite, and in the separation of limestone and serpentine; ‡ J. Lawrence Smith§ has remarked the solubility of anglesite in ammonium citrate; calamine is sometimes distinguished from willemite by its gelatinizing with acetic acid; || and mineralogists often resort to the comparatively weak acetic acid for the purpose of "cleaning up" minerals associated with the easily soluble calcite. So far as we can learn, no systematic examination of the action of organic acids on minerals has previously been made; yet the field proves to be wide and fertile.

During a mineralogical excursion in the summer of 1876, among the rugged mountains of western North Carolina, the impracticability of transporting liquid mineral acids suggested to the writer an examination of the behavior of minerals with solutions of citric and tartaric acid, which are capable of being carried in the solid state. Subsequently a few preliminary trials established the fact that our preconceived notions of the weakness of organic acids as respects minerals were erroneous, and led to the investigation recorded in the following pages.

It became necessary at the very outset to collect a considerable number of minerals in a state of great purity and of normal physical condition: our own small collection supplied these in part, but we would have been embarrassed in this research without the kind assistance of Prof. Thomas Egleston, who generously placed the rich treasures of the School of Mines' mineralogical collection at our disposal, and to whom we tender our sincere thanks.

* W. Gould Levison, *American Journal of Science*, [2] I., 240.

† *American Journal of Science*, [2] XXVIII, 180, and XLII, 64.

‡ *Geol. Canada*, 1863, 609.

§ *American Journal of Science*, [2] XX, 244.

|| Dana's *System Min.*, 5th edition, p. 408.

Since the hardness, coherence, and solubility of minerals vary greatly in different specimens of a single species, the behavior of minerals with acids, whether inorganic or organic, depends in large measure upon the condition of the particular sample under examination. An absolutely thorough investigation, therefore, would embrace the reactions of several specimens of each mineral; as desirable as this would seem to be, it was found that on the whole so laborious an undertaking was superfluous, and for two reasons; first, the decomposing action of the acids on different samples of the same species differs in degree and not in kind; and, secondly, the behavior of different species nearly related is so similar that the observations made on each serve to mutually control.

2. The following list contains the names of the minerals which were submitted to the action of organic acids, their formulæ as given by Prof. Dana, the condition of the specimens, and the locality of each so far as could be ascertained. Where two or more specimens of a single species are named, they are numbered, for convenience of reference in subsequent pages.

Within the groups I, Carbonates; II, Sulphides; III, Oxides; IV, Sundries; V, Silicates, the minerals are given in the order, and with the formulas, which they have in Dana's System of Mineralogy.

I. CARBONATES.

MINERAL.	FORMULA.	DESCRIPTION.	LOCALITY.
Calcite, (1)	$\text{Ca } \ddot{\text{C}}$	fine-grained marble	Italy.
" (2)		transparent crystals	Bergen, N. J.
Dolomite, (1)	$\text{Ca } \ddot{\text{C}} + \text{Mg } \ddot{\text{C}}$	coarse crystalline	Westchester Co., N. Y.
" (3)		{ fine granular, with flakes of graphite, }	{ Amity, N. Y.
Gurhofite	$2\text{Ca } \ddot{\text{C}} + \text{Mg } \ddot{\text{C}}$	massive, subtransl.	Montville, N. J.
Ankerite	$\text{Ca } \ddot{\text{C}} + (\text{Mg } \ddot{\text{C}} \text{ Fe } \ddot{\text{C}} \text{ Mn } \ddot{\text{C}})$	crystalline	Nova Scotia.
Magnesite, (1)	$\text{Mg } \ddot{\text{C}}$	massive	Westchester, Pa.
" (2)		compact	Piedmont.
Siderite, (1)	$\text{Fe } \ddot{\text{C}}$	massive	Roxbury, Conn.
" (2)		massive	Dauphny, France.
Rhodochrosite ...	$\text{Mn } \ddot{\text{C}}$	massive, pure	Austin, Nev.
Smithsonite	$\text{Zn } \ddot{\text{C}}$	earthy, massive	Sterling, N. J.

6 *Organic Acids in the Examination of Minerals.*

Witherite.....	Ba $\ddot{C}$	granular, massive.....England.
Strontianite.....	Sr $\ddot{C}$	granular.....Westphalia.
Cerussite.....	Pb $\ddot{C}$	crystalline.....Phoenixville, Pa.
Barytocalcite.....	Ba $\ddot{C}$ + Ca $\ddot{C}$	massive and cryst.....Alston Moor, Eng.
Malachite.....	Cu $\ddot{C}$ + Cu H	compact.....Russia.
Azurite.....	2Cu $\ddot{C}$ + Cu H	massive, earthy.....Germany.

II. SULPHIDES

MINERAL.	FORMULA.	DESCRIPTION.	LOCALITY.
Stibnite.....	Sb, S,	fibrous, massive.....	Arkansas.
Molybdenite.....	Mo S,	scales.....	Germany.
Argentite, (1).....	Ag S	with PbS and SiO ₂	Virginia City, Nev.
" (2).....		massive, pure.....	Cornucopia, Nev.
Galenite.....	Pb S	cleavable, massive.....	Missouri.
Bornite, (1).....	(Cu Fe) S	massive.....	Acton, Canada.
" (2) and (3)...		two samples, very pure.....	Harvey Hill, Can.
" (4).....		massive.....	Germany.
Sphalerite.....	Zn S	massive.....	Friedensville, Pa.
Chalcocite, (1) and (3)	Cu S	massive.....	Chill, S. A.
" (2).....		crystals.....	Bristol, Conn.
Cinnabar.....	Hg S	granular, massive.....	California.
Pyrrhotite, (1).....	Fe, S,	granular, massive.....	North Carolina.
" (2).....		granular, massive.....	Litchfield, Conn.
" (3).....		massive.....	Anthony's Nose, N. Y.
Niccolite.....	Ni As	massive.....	Tangerhansen.
Smaltite.....	(Co Fe Ni) As ₂	massive.....	Germany.
Pyrite, (1).....	Fe S ₂	massive.....	Germany.
" (2).....		massive.....	Freiberg, Saxony.
" (3).....		massive.....	Colorado.
Chalcopyrite, (1).....	Cu S . Fe S . Fe S ₂	massive.....	Acton, Can.
" (2).....		massive.....	Harvey Hill, Can.
" (3).....		massive.....	Colorado.
" (4).....		massive.....	Ore Knob, N. C.
Ullmannite.....	Ni S ₂ + Ni (Sb As),	.....	Petersbach.
Marcasite.....	Fe S ₂	crystalline.....	Germany.
Arsenopyrite.....	Fe S ₂ + Fe As ₂	massive.....	Norwalk, Conn.
Bournonite.....	3 (Cu Pb) S + Sb ₂ S ₃	massive.....	Germany.
Tetrahedrite.....	4Cu S + Sb ₂ S ₃	granular.....	Freiberg, Saxony.

III. OXIDES.

MINERAL.	FORMULA.	DESCRIPTION.	LOCALITY.
Cuprite	Cu	massive.....	Siberia.
Zincite	Zn	massive.....	Sterling, N. J.
Hematite, (1).....	Fe	micaceous.....	Michigan.
" (2).....		red, massive	Missouri.
Magnetite, (1).....	Fe ²⁺ Fe	massive, granular.....	Canada.
" (2).....		.....	Saratoga Co., N. Y.
Limonite, (1)	Fe ₂ O ₃ ·H ₂ O	botryoidal.....	Salisbury, Conn.
" (2)		fibrous.....	Anniston, Ala.
Franklinite	(Fe Zn Mn) (Fe Mn)	massive	Franklin, N. J.
Chromite	Fe Cr	massive.....	California.
Uraninite	U ₂ O ₅	massive.....	Bohemia.
Hausmannite.	Mn ₂ O ₃	crystalline.....	Thuringia.
Pyrolusite.....	MnO ₂	massive, granular.....	New Brunswick. (?)
Manganite	Mn ²⁺ H	crystalline	Defeld, Hartz Mts.
Pelomelane	(Ba Mn) Mn + Mn	massive.....	Germany.
Wad	R Mn + H	earthy.....	Saxony.
Brucite.....	Mg H	foliated	Texas, Pa.

IV. SUNDRIES.

MINERAL.	FORMULA.	DESCRIPTION.	LOCALITY.
Apatite	Ca ²⁺ P ³⁺ + $\frac{1}{2}$ Ca (Cl F)	crystals	Mitchell Co., N. C.
Vivianite.....	Fe ²⁺ P ³⁺ + 8H ₂ O	radiated, fibrous.....	Mullica Hill, N. J.
Pyromorphite.....	3Pb ²⁺ P ³⁺ + Pb Cl	crystalline.....	Bohemia.
Fluorite.....	Ca F ₂	translucent, massive...	Muscalonge Lake, N. Y.
Cryolite.....	3Na F + Al ₂ F ₆	massive	Greenland.
Anglesite	Pb SO ₄	.....	Phoenixville, Pa.
Gypsum.....	Ca S + 2H ₂ O	crystals	Montmartre, France.
Samarskite.....	(R ³⁺ R ⁴⁺) ₂ Sb ₂ O ₇	massive.....	Yancey Co., N. C.
Silver.....	Ag	pure silver.....	?
Copper.....	Cu	copper foil.....	?
Iron.....	Fe	iron wire.....	?
Zinc	Zn	granulated	Bethlehem, Pa.
Lead	Pb	test-lead	?
Tin	Sn	granulated	?
Aluminium	Al	foil.....	France.
Antimony.....	Sb	massive, crystalline....	?
Bismuth	Bi	massive, crystalline....	?

V. SILICATES.

MINERAL.	FORMULA.	DESCRIPTION.	LOCALITY.
Wollastonite...	Ca Si	fibrous.....	Natural Bridge, N. Y.
Diopside.....	$(\text{Ca Mg}) \text{Si}$	crystals.....	Tyrol.
Augite.....	$(\text{Ca Mg Fe}) (\text{Si Al}^{\frac{1}{2}})$	crystals.....	Sicily.
Rhodonite.....	Mn Si	massive.....	Franklin, N. J.
Spodumene....	$\text{H}^+ \text{Si}^2 + 4\text{Al Si}^2$	crystals.....	Windham, Me.
Hornblende....	$(\text{H}^+ \text{H}) (\text{Si Al}^{\frac{1}{2}})$	massive.....	New York City.
Chrysotile....	$(\text{Mg Fe})^2 \text{Si}$	massive.....	North Carolina.
Olivine.....	$(\text{Mg Fe})^2 \text{Si}$	granular.....	Sandwich Islands.
Willemite....	$\text{Zn}^2 \text{Si}$	massive.....	Franklin, N. J.
Almandite....	$(\text{Fe}^2 + \frac{1}{2}\text{Al})^2 \text{Si}^2$	crystals.....	Sterling, N. J.
Epidote.....	$[\frac{1}{2}\text{Ca}^2 + \frac{1}{2}(\text{Al Fe})] \text{Si}^2$	massive.....	Ducktown, Tenn.
Biotite.....	$[\frac{1}{2}(\text{Mg K})^2 + \frac{1}{2}(\text{Al Fe})^2] \text{Si}^2$	laminae.....	Westchester Co., N. Y.
Muscovite.....	$(\text{H}^+ \text{H}), \text{Si}^2 + \frac{1}{2}\text{Si}$	laminae.....	North Carolina.
Wernerite.....	$[\frac{1}{2}(\text{Na Ca})^2 + \frac{1}{2}\text{Al}]^2 \text{Si}^2 + \text{Si}$	massive.....	Gouverneur, N. Y.
Labradorite...	$[\frac{1}{2}(\text{Ca Na})^2 + \frac{1}{2}\text{Al}]^2 + \frac{1}{2}\text{Si}^2$	massive.....	Turin, N. Y.
Albite.....	$(\frac{1}{2}\text{Na}^2 + \frac{1}{2}\text{Al})^2 \text{Si}^2 + 6\text{Si}$	massive.....	Yancey Co., N. C.
Orthoclase....	$(\frac{1}{2}\text{K}^2 + \frac{1}{2}\text{Al})^2 \text{Si}^2 + 6\text{Si}$	massive.....	New York City.
Chondrodite...	$\text{Mg}^2 \text{Si}^2 [\text{F}]$	crystals.....	Sparta, N. J.
Tourmaline....	$(\text{H}^+ \text{H}^+ \text{B})^2 \text{Si}^2 [\text{F}]$	black crystals....	New York City.
Kyanite.....	Al Si	crystals.....	Buncombe Co., N. C.
Datolite.....	$(\text{Ca}^2 \text{H}^+ \text{B}) \text{Si}$	crystals.....	Lake Superior.
Pectolite.....	$(\frac{1}{2}\text{Ca} + \frac{1}{2}\text{Na} + \frac{1}{2}\text{H}) \text{Si}$	crystals.....	Bergen, N. J.
Chrysocolla....	$\text{Cu Si} + 2\text{H}$	massive.....	Lake Superior.
Calamine.....	$\text{Zn}^2 \text{Si} + \text{H}$	crystalline.....	Friedensville, Pa.
Prehnite.....	$(\frac{1}{2}\text{H}^2 + \frac{1}{2}\text{Ca}^2 + \frac{1}{2}\text{Al})^2 \text{Si}^2$	uniform, massive.	Scotland.
Apophyllite...	$[\frac{1}{2}\text{H} + \frac{1}{2}(\frac{1}{2}\text{K} + \frac{1}{2}\text{Ca})]^2 \text{Si} + \text{H Si}$	crystals.....	Bergen, N. J.
Natrolite, (1)...	$8\text{Si}, \text{Al}, \text{Na}, 2\text{H}$	dark, massive....	Württemberg.
" (2)...		white, fibrous....	Bergen, N. J.
Analcite.....	$4\text{Si}, \text{Al}, \text{Na}, 2\text{H}$	fine crystals....	Lake Superior.
Chabasite....	$4\text{Si}, \text{Al} [\frac{1}{2}\text{Ca} + \frac{1}{2}(\text{Na K})] 6\text{H}$	crystals.....	Nova Scotia.
Stilbite.....	$6\text{Si}, \text{Al}, \text{Ca}, 6\text{H}$	crystals.....	Nova Scotia.
Talc.....	$(\frac{1}{2}\text{H} + \frac{1}{2}\text{Mg}) \text{Si}$	massive.....	North Carolina.
Serpentine....	$\text{Mg}_2\text{Si} + \text{H}$	massive.....	Newburyport, Mass.
Retinalite....	$\text{Mg}_2\text{Si} + \text{H}$	waxy, transl.....	Montville, N. J.
Chrysotile....	$\text{Mg}_2\text{Si} + \text{H}$	silky, fibrous....	Montville, N. J.
Deweyite.....	$(\frac{1}{2}\text{Mg} + \frac{1}{2}\text{H})^2 \text{Si} + \frac{1}{2}\text{H}$	massive, transl...	Eye, N. Y.
Ripidolite....	$8(\frac{1}{2}\text{Mg}^2 + \frac{1}{2}\text{Al Fe}) 9\text{Si}, 12\text{H}$	laminae.....	North Carolina.

[Ninety Species, one hundred and twenty Specimens.]

3. The organic acids employed in this investigation were chiefly citric, tartaric, and oxalic; a few tests were made also with malic, formic, acetic, benzoic, pyrogallie, and picric acids. Of the solid acids, solutions saturated in the cold were used, unless otherwise specified; of the liquid acids, ordinary commercial products. The behavior of the minerals with these acids was studied in a very simple manner: the mineral to be examined was carefully freed from its associated gangue or mineral, finely pulverized in an agate mortar, and a portion placed in a test-tube; the solution of the acid was then added, and the resulting phenomena, in the cold and on boiling, carefully noted. Sometimes satisfactory conclusions were reached only by comparison of a number of tests under varying conditions, as to amount of acid, time of heating, etc. In some cases, to be mentioned in due course, the partial decomposition of the mineral was ascertained by filtering from the residue and testing the solution with an appropriate reagent; in others, by examining the disengaged gas with a suitable test-paper.

CARBONATES.

4. The natural carbonates dissolve with effervescence more or less readily in dilute and strong, cold and hot solutions of citric, tartaric, oxalic, malic, formic, benzoic, acetic, pyrogallie, and picric acids, the relative power of these acids being approximately in the order in which they are named. The behavior of the carbonates with citric acid may be summarized as follows:

(a) Calcite, guruhofite, witherite, strontianite, cerussite, baryto-calcite, and malachite dissolve rapidly in the cold.

(b) Dolomite, ankerite, rhodochrosite, smithsonite, and azurite are more feebly attacked in the cold.

(c) Magnesite and siderite are not attacked in the cold.

On heating, all the above carbonates dissolve very rapidly, except siderite, which is more slowly attacked. From strong, nearly neutral solutions of calcite, guruhofite, and some other calcium minerals, a white precipitate of calcium citrate forms on cooling; cerussite also deposits a white precipitate on cooling.

It is evident that a solution of citric acid effects the decomposition of mineral carbonates with sufficient ease to render it extremely useful where hydrochloric acid can not be conveniently employed. The organic acid acts, however, somewhat more slowly; in fact, time appears to be an important factor in studying these reactions. On some minerals the organic acid has at first no effect, and an appreciable time elapses before bubbles of carbonic anhydride appear, indicating the decomposition of the mineral; this is especially noticeable with dolomite and azurite. The time of incipient action varies also with the acid employed.*

Owing to the viscosity of a concentrated solution of citric acid, the liberated gas has difficulty in escaping, and often remains attached in bubbles to the powder until sufficiently large bubbles have formed to ascend through the syrupy liquid; this, of course, has reference to examinations made in the cold. Moreover, the precaution was observed of distinguishing between the escape of bubbles of air entangled by the powdered mineral and a true liberation of carbonic anhydride. These minute details are mentioned, because observation of them is necessary to obtain the same results as those recorded in the first part of this section. Magnesite and siderite were repeatedly tested, and always refused to effervesce with a cold solution of citric acid, a reaction which distinguishes them from other carbonates.

5. In making this investigation we have constantly borne in mind the possible employment of the methods in the field, and have conducted the tests in the simplest manner with that end in view. Since it is seldom convenient in field work to obtain the minerals in fine powder, an examination was made of the action of citric acid on the *massive* carbonates; and by

* The interesting subject of the Velocity of Chemical Reactions has recently been investigated in certain cases by Boguski and Kajander (Berichte d. deutschen Chem. Ges. Berlin, ix, 1646, and x, 34). They find that when nitric, hydrochloric, and hydrobromic acids, of the same concentration, act upon marble, the velocity of evolution of carbonic anhydride is inversely proportional to their molecular weights. Cf. American Journal of Science, [3] xii p. 239. It will be interesting to ascertain whether this law holds good with organic acids.

way of comparison the behavior of the same with hydrochloric acid was also noted. The results may be summarized as follows: 1, signifying that the minerals effervesce quickly when the acid is dropped on their smooth surfaces; 2, that they are feebly and slowly attacked; 3, that they do not effervesce.

Mineral.	HCl. Sp. Gr. 1.055	Citric Acid.
Calcite.....	1	1
Dolomite.....	3	3
Gurhofite.....	1	1
Aukerite.....	2	3
Magnesite.....	3	3
Siderite.....	3	3
Rhodochrosite.....	3	3
Smithsonite.....	2	3
Witherite.....	1	2
Strontianite.....	1	2
Baryto-calcite.....	1	2
Malachite.....	1	2
Azurite.....	2	†

Porous minerals, and those having highly polished cleavage or crystalline surfaces, appear to resist the action of the acids, but for very different reasons; the former (smithsonite, for example) absorb the liquid and conceal its action within their pores; the latter (dolomite, siderite, etc.) seem to repel the liquid, or rather to prevent its actual contact. In the latter case the action of the acid may be rendered visible by scratching the surface with a knife and applying the acid liquid to the roughened surface or to the small amount of powder produced by the scraping. The observations above recorded were made on smooth surfaces.

In earthy minerals, the acid should be applied repeatedly at the same point until, the pores being filled, the action of the acid on the surface becomes apparent.

6. The mineral carbonates behave with a solution of tartaric acid much in the same manner as with citric acid, but the tartrates being in general a little less soluble than the citrates, crystalline precipitates form more readily on cooling the saturated solutions.

The results recorded below were obtained with a solution saturated in the cold :

(a) Calcite, *gurhofite*, *witherite*, *strontianite*, *cerussite*, and *baryto-calcite* dissolve readily in the cold ; on boiling, the action is increased, and the solutions deposit crystalline precipitates on cooling ; the precipitates of calcium tartrate and of barium tartrate form readily, and may be recognized with a little experience. (Cf. §10.)

(b) *Dolomite*, *ankerite*, *rhodochrosite*, *smithsonite*, *malachite*, and *azurite* effervesce feebly in the cold, and dissolve rapidly on heating. *Dolomite* and *smithsonite* deposit crystals on cooling the solutions ; *malachite* yields a bluish green precipitate ; *azurite* dissolves readily without residue.

(c) *Magnesite* and *siderite* are not attacked in the cold, but dissolve readily on heating. The specimen of *siderite* from *Roxbury* effervesced very slightly in the cold and appeared to be more soluble than the specimen from *Dauphin*.

7. Oxalic acid decomposes the carbonates in a similar manner, forming, however, still more insoluble precipitates, which are in some cases characteristic of the bases contained in the minerals ; especially is this true of the white pulverulent calcium oxalate, the light yellow granular ferrous oxalate, the beautifully feathered crystals of barium oxalate, and the heavy white precipitate of lead oxalate. *Ankerite* contains enough ferrous carbonate to communicate a decided yellow color to the insoluble calcium salt, by the formation of ferrous oxalate. *Baryto-calcite* dissolves freely on boiling, with formation of insoluble calcium oxalate ; by decanting the supernatant liquid it deposits as it cools the feathered needles characteristic of acid barium oxalate, easily distinguishable from the stouter, lengthened, monoclinic prisms of oxalic acid which likewise form in concentrated solutions.

Magnesite, which resists the action of cold citric and tartaric acids, succumbs to oxalic acid. *Siderite* is also more readily decomposed. *Malachite* and *azurite* are feebly attacked in the cold, dissolve slowly on heating, and yield precipitates which are respectively grayish-green and bluish-white in color. *Cerussite* and *smithsonite* also furnish solutions which deposit crystalline precipitates on cooling.

8. Acetic acid does not act so energetically on the mineral carbonates as do the preceding; moreover, on boiling, the volatile acid distills off and the solution becomes weaker as the heating is continued; whereas with solutions of the solid acids, boiling increases their concentration and their decomposing power. We conjecture that experimenters in this direction have been deterred from further research by the unsatisfactory nature of the reactions with acetic acid. And yet, if we may trust the ancient chronicles of Rome, the behavior of minerals with this acid was investigated at a very early period; we refer to that much disputed tradition which represents the celebrated Carthaginian general, Hannibal, applying vinegar to the removal of rocks that obstructed his passage across the Alps, in his march on the Roman capital:

"Diducit scopulos et montem rumpit aceto."

Glacial acetic acid does not in the slightest degree dissolve calcite; even pure precipitated calcium carbonate does not effervesce when boiled with glacial acetic acid; but on adding one-fourth part of water, effervescence begins at once and the carbonate dissolves freely.

The behavior of carbonates with acetic acid may be summarized as follows (Sp. gr. of acid = 1.037).

(a) Calcite, guruhofite, witherite, cerussite, baryto-calcite, and strontianite effervesce freely in the cold and dissolve rapidly on heating.

(b) Dolomite, ankerite, smithsonite, and azurite effervesce slightly in the cold, the action being increased on boiling.

(c) Magnesite, siderite, rhodochrosite, and malachite are not attacked in the cold, and dissolve more or less readily on boiling.

9. Formic acid (Sp. gr.=1.060) acts rather more powerfully than acetic; cerussite gives a peculiarly beautiful and characteristic deposit of lustrous white crystals. Malic acid also acts quite energetically; but the difficulty of obtaining it in a state of purity, and its high price, will prevent its use in this connection. It does not seem especially desirable to extend the list of organic acids; for though their number is legion,

but few are commercial articles; some interest might be attached to a comparison of their decomposing power, but a practical application to the examination of minerals is very doubtful. To test the probabilities of their action, however, a few experiments were made with solutions of picric, benzoic, and pyrogallic acids.

A strong hot solution of picric acid (carefully freed from nitric acid by re-crystallization) decomposes calcite, dolomite, and witherite very readily. A moderately strong hot solution of benzoic acid dissolves calcite freely, and a crystalline precipitate falls on cooling. Dolomite dissolves on boiling. Pyrogallic acid attacks calcite in the cold, and dissolves it on boiling, with formation of a white precipitate, while the supernatant liquid turns dark in color through absorption of oxygen.

MICROSCOPICAL EXAMINATION OF THE CRYSTALLINE PRECIPITATES.

By JOHN H. CASWELL.

10. The crystalline precipitates obtained in these reactions are in some measure distinguishable by the naked eye, but microscopical examination of the varied forms develops interesting peculiarities. For this investigation we have had the good fortune to secure the skill, as well as the pencil, of our friend Mr. John H. Caswell, of the School of Mines, Columbia College, who places us under obligation by communicating the following results of his study.

"The crystalline deposits were obtained by treatment of the different minerals named, with hot solutions of the acids, in test-tubes, and concentration of the solution when necessary. In addition to the crystalline forms of the acids themselves, tartaric and oxalic, the following substances were examined: Hydro-calcium tartrate, neutral calcium tartrate, hydro-barium tartrate, calcium oxalate, hydro-barium oxalate, hydro-strontium oxalate, ferrous oxalate, formate of lead, and calcium citrate. The precipitates resulting from treatment of the minerals were compared with similar precipitates formed from chemically pure material.

Tartaric Acid.—The most usual and characteristic forms

observed were triangular-shaped crystals, of very beautifully sharp and distinct outline. The smaller ones appeared to be without any modifications, as in Plate I, Fig. 4, but some of the larger and thicker ones had faces and planes on the angles and edges similar to those in Fig. 2. The same crystals viewed in a different position appeared as in Fig. 5, which forms were often grouped, together with the triangles, into stellate masses, Fig. 6. Flat, tabular crystals, apparently with domes and prismatic faces, were also observed. They were remarkable, owing to the terminations being different on the same crystal, thus occasioning a somewhat wedge-shaped form, as in Figs. 1-3. These tabular crystals are quite large, and often have inclosures of small acicular crystals and cavities. Very small needle-like crystals were also observed in the same slide as those already mentioned.

Hydro-calcium tartrate (Figs. 7 to 12).—From a solution of calcite in an excess of tartaric acid, crystals were obtained, strongly resembling orthorhombic or monoclinic forms, consisting of prism and dome, as shown in the figures. These crystals were quite small, but very beautifully sharp and distinct, and gave bright colors in polarized light. The figures show forms almost identical, but seen in different positions. The crystals were then twice boiled with water, to remove any excess of tartaric acid, the only effect being to mass the crystals in groups and to round their angles somewhat, although some good individuals were seen. The water solution was then evaporated and some very sharp and good crystals obtained, having the same characteristic face and angles as in the figure, but generally larger and sharper than those before observed. These forms, then, belong undoubtedly to hydro-calcium tartrate, tartaric acid being entirely too soluble to have furnished crystals in this way. Sometimes the crystals are in long, slender prisms, but always with the characteristic dome-like termination; and in some of the larger ones the pinacoid is present.

Gurhofte, treated with tartaric acid, gave the forms already described, and also some transparent masses of irregular shape, having no crystalline characteristics.

Dolomite, treated as above, also afforded some good crystals of hydro-calcium tartrate, very easily recognized among other irregular fragments or masses of no particular form.

Neutral calcium tartrate, obtained by treating a concentrated solution of tartaric acid with an excess of calcite, gave very minute needles, which in almost every case were grouped in small radiated circular masses, much resembling the spherulites of volcanic rocks. The outlines of these groups are sharp and distinct, always perfectly round, sometimes having the central part transparent, but no particular crystalline form could be made out.

Hydro-barium tartrate (Fig. 13), from witherite and tartaric acid, crystallizes in very delicate, long, almost capillary, acicular crystals, which are often grouped in bundles, the needles lying parallel to each other. A few characteristic crystals, probably hydro-calcium tartrate, having the form and faces (as previously mentioned) of prism and dome, were easily recognized; they doubtless proceeded from the calcium contained in the witherite. It is interesting to be able so easily, by the aid of the microscope, to distinguish a small percentage of calcium in the presence of a large quantity of barium. The needles of hydro-barium tartrate give fine colors in polarized light.

Oxalic acid forms long prismatic crystals, quite stout, and generally terminated with domes, similar to those faces in hydro-calcium tartrate; but apparently of much flatter angles. When carefully made, the crystals are sharp and distinct in outline and terminations, but the mass much oftener crystallizes in indistinctly radiated groups, in which the forms can scarcely be distinguished. Oxalic acid, as is well known, gives beautiful colors in polarized light.

Calcium oxalate is an amorphous powder, and, even under the microscope, appears to be in minute masses, almost opaque and with no distinguishable crystalline characteristics.

Hydro-barium oxalate, from witherite and oxalic acid (Figs. 14-16), crystallizes in large, beautiful forms, very characteristic, and different from anything before noticed. The crystals have the shape of a spear-head or arrow-head, being built up

of many small crystals arranged on a straight rib or spine somewhat like a feather. The spear-headed forms are deeply striated or furrowed, and inclose large fluid-cavities; they give beautiful colors also in polarized light. A few simple crystals, as in Fig. 14, are apparently monoclinic or triclinic; and the edges or sides of the feather-like forms generally terminate in similar small, distinctly outlined crystals, placed on the extremity of the lateral ribs.

Very striking were the forms (Figs. 17, 18) obtained from treating baryto-calcite with oxalic acid. They consisted, first, of the large spear-headed or feather-shaped crystal groups, as shown in the sketch, in which the mode of formation is very easily seen, especially the simple crystals terminating the lateral ribs. The latter are curved upward a little, but seem to be nearly at right angles to the main spine or axis. Besides these forms, amorphous calcium oxalate was observed, and also some long, columnar crystals of oxalic acid. By allowing the calcium oxalate to settle, and decanting and crystallizing the clear solution, the best and cleanest crystals of hydrobarium oxalate can be obtained, of tolerably large size.

Hydro-strontium oxalate (Figs. 19, 20), from strontianite and oxalic acid, gave very small crystals, somewhat resembling those of hydro-calcium tartrate, but apparently with much flatter angles. One form, Fig. 20, seemed to be made up of prism, pinacoid, and domes, probably orthorhombic or monoclinic. Other crystals, probably pyramidal, appeared to be minute rhombs (Fig. 19), sometimes in groups.

Ferrous oxalate (Fig. 21), from siderite and oxalic acid, gave yellow crystals, exceedingly minute, but nevertheless quite distinctly outlined. Their form was prismatic with a flat or basal termination.

The same crystals were abundantly obtained from ankerite also; but the crystalline mass was of a lighter yellow than that formed from siderite, owing to admixture of calcium oxalate.

Formate of lead, from cerussite and formic acid, crystallized in quite large acicular forms, sharp and transparent, but terminated with rounded faces, the exact nature of which

could not be determined. The crystals are generally comparatively short and stout, being quite different from the hydro-barium tartrate, which is almost capillary in character. Some of the larger crystals of formate of lead are thick and cloudy, apparently from the presence of microlites and fluid cavities.

Calcium citrate, from citric acid and calcite, had no crystalline appearance, being in the form of very minute masses, and is probably amorphous as thus obtained."

METALS AND ORGANIC ACIDS.

11. That citric and tartaric acids dissolve iron and zinc, with evolution of hydrogen gas, is a well-known fact, stated in many handbooks of chemistry.*

Crommydis has recently taken advantage of the solubility of zinc in oxalic acid to prepare glycollic acid ($\text{H}_2\text{C}_2\text{H}_3\text{O}_3$), a reaction in which nascent hydrogen plays an important part.†

In repeating and extending these experiments we have made the following observations: Iron, zinc, and magnesium dissolve readily in cold saturated solutions of citric, tartaric, oxalic, and malic acids, as well as with formic (Sp. Gr. = 1.060) and acetic acids (Sp. Gr. = 1.037), evolving hydrogen more or less freely; on heating, the action becomes violent. Magnesium is attacked by citric and other acids violently, the liquid becoming much heated.

A cold-saturated solution of citric acid, diluted with half its volume of water, attacks zinc slowly in the cold; on boiling, hydrogen comes off freely and continues to do so after cooling for a long time; the disengagement of gas being slow but steady, and under favorable conditions lasting for twenty-four hours. If the solution becomes very concentrated, an insoluble citrate of zinc precipitates, soluble, however, in water.

Tartaric acid acts on zinc feebly in the cold; on boiling, solution ensues, and at the same time the hot liquid becomes

* Cf. *Handwörterbuch der Chemie*, article "Citronensäure."

† *Bull. soc. chim.*, xxvii. p. 3, 1877.

milky from the formation of an insoluble tartrate of zinc; on cooling, the solution becomes clear and a precipitate settles.

Oxalic acid in concentrated solution attacks zinc in the cold immediately; but the action soon ceases, owing to the surface of the zinc becoming coated with a quite insoluble zinc oxalate; on heating to boiling, the evolution of hydrogen is resumed, but is again arrested in a short time from the same cause. On cooling, a fine precipitate forms.*

SULPHIDES.

12. After experiencing the solvent power of organic acids described in the preceding section, we were prepared to discover many sulphides yielding to them, though we confess to surprise at finding this action taking place even in the cold. Such is the case with four out of the eighteen sulphides selected for examination, viz.: stibnite, galenite, sphalerite, and pyrrhotite. The tests were made as follows: the pulverized minerals were placed in test-tubes, a concentrated solution of citric acid was added, and a piece of paper moistened with plumbic acetate was suspended in each tube, which was then corked. After standing twelve hours at the ordinary temperature, the blackened test-papers gave evidence of the decomposition. Sphalerite seems to be the most readily decomposed, the sulphureted hydrogen coming off immediately. On heating, the disengagement of sulphureted hydrogen is very marked; with boiling citric acid, bornite and bournonite, in addition to those just mentioned, yield sulphureted hydrogen. One sample of argentite, containing mingled galenite, gave a reaction for sulphureted hydrogen; but

* Experiments were made to test the applicability of these methods of generating hydrogen to the detection of arsenic by Marsh's apparatus. If a solution containing arsenic be introduced into a flask in which hydrogen is evolved from the action of citric acid on zinc, the disengagement of gas is greatly augmented and arseneted hydrogen forms at once. Owing to the imperfect solubility of zinc citrate, the action soon ceases. With tartaric acid the same objection arises, while oxalic acid is out of the question. This difficulty does not apply to magnesium, which might be employed in an apparatus similar to that described by Dr. John C. Draper (*American Chemist*, II. 436). By using distilled magnesium and re-crystallized citric acid, the absence of arsenic in the materials used for toxicological researches could be placed beyond suspicion.

a purer specimen was not attacked. With bournonite the reaction is feeble.

Pyrite, marcasite, molybdenite, chalcocite, cinnabar, argentite, niccolite, smaltite, chalcopyrite, ullmannite, arsenopyrite, and tetrahedrite resist the action of citric acid. Tartaric and oxalic acids act in a similar manner, both in the cold and on boiling. A comparison of the behavior of nine organic acids with stibnite gave the following results:

(a) Stibnite heated with citric, tartaric, and oxalic acids yields sulphureted hydrogen freely and goes into solution.

(b) With malic, benzoic, and pyrogallic acids, sulphureted hydrogen comes off feebly and the mineral dissolves imperfectly.

(c) With formic and acetic acids no gas is evolved and the mineral is not dissolved.

(d) With picric acid no gas is evolved, but the mineral is partially dissolved.

It is noticeable that the *liquid* acids are powerless to effect decomposition. (§ 8.)

13. The action of the organic acids on mineral sulphides is not so decided as that of the mineral acids; but this is no disadvantage, since it affords additional means of determining them. On examining the reactions recorded in the preceding section, it will be found that bornite and pyrrotite are decomposed by citric acid, while their kindred compounds, pyrite and chalcopyrite (as well as chalcocite) are not. In order to establish satisfactorily this difference of behavior, several specimens of each of these minerals, from various localities, were carefully tested.

(a) Four samples of bornite were heated with a concentrated solution of citric acid, and each gave a strong reaction for sulphureted hydrogen; of four specimens of chalcopyrite, treated in the same manner, two gave no traces of this gas, and two gave mere traces on long boiling; three samples of chalcocite yielded no traces of sulphureted hydrogen.

(b) Three specimens of pyrite heated with citric acid gave no traces of the gas, and three of pyrrotite liberated it both in the cold and freely on boiling. On the other hand all the specimens named are decomposed by hydrochloric acid, except one specimen of pyrite (from Germany).

It is evident, then, that citric acid may be used to distin-

guish pyrrhotite from pyrite, and bornite from chalcocite or chalcopyrite. The presence of galenite in argentite may also be ascertained by this method, since the former yields H_2S even in the cold, while the latter is not decomposed on boiling.

OXIDES.

14. A few of the mineral oxides examined are attacked by the organic acids in the cold; brucite dissolves slowly, but to a considerable extent, in cold citric acid; the manganese oxides, hausmannite, pyrolusite, manganite, psilomelane, and wad, decompose the organic acid with evolution of carbonic anhydride; the reaction begins in the cold, and on applying heat proceeds rapidly, with a lively effervescence.



Manganite is not so soluble as the others, probably because the oxidizing power of the sesquioxide is less than that of manganese dioxide. The minerals are apparently more quickly and completely dissolved by oxalic acid than by citric acid.

Zincite, cuprite, and limonite are attacked by boiling citric acid, the latter but slightly. Hematite, magnetite, franklinite, and chromite are not attacked. In testing these minerals, conclusions were based on the reactions of the filtrates; in employing ferrocyanide of potassium to test the citric acid solutions of the iron oxides, we observed that the organic acid exerts a reducing action on the ferrocyanide, and produces a bluish precipitate proceeding from this reagent itself. This is especially noticeable on boiling, a light bluish-green precipitate forming abundantly. Tartaric and oxalic acids act similarly.

The oxides behave with tartaric acid in all respects as with citric.

SUNDRY MINERALS.

15. A few minerals not closely related were examined as to their behavior with citric acid. Gypsum appears to be somewhat more soluble in a concentrated solution of citric

acid than in water. Apatite is feebly attacked on boiling. Vivianite is readily soluble. Pyromorphite and anglesite are partly decomposed even in the cold, as shown by the behavior of the filtrates with hydrosulphuric acid.

Fluorite, cryolite, and samarskite are not attacked, as might be anticipated.

SILICATES.

16. Those silicates which are decomposed by hydrochloric acid, either with or without the formation of a jelly, are likewise attacked more or less strongly by a hot solution of citric acid. The minerals were examined as follows:—their behavior with strong hydrochloric acid was first ascertained, and they were then heated with a concentrated solution of citric acid; the solution becomes viscid by concentration, and the gelatinous silica is best seen by diluting with water and agitating. Very careful pulverization of the mineral is in most cases indispensable. The solubility of the mineral was also tested by filtering from the silica and undissolved material, and examining the solution with an appropriate reagent. Owing to the power possessed by citric acid (in common with other organic bodies) of preventing precipitation of salts which are otherwise insoluble, care was had to select those reagents which were least affected; in this we were aided by a table contained in Dr. Hermann Grothe's paper entitled, "*Ueber das Verhalten der Metalloxydaufösungen gegen Alkalien bei Gegenwart nicht-flüchtiger organischer Substanzen und ueber den Nachweis der Metalloxyde in solchen Lösungen.*"*

So far as possible, color reactions were employed.

The results are summarized below:—1, signifying minerals which decompose readily; 2, those which are attacked with difficulty; 3, those which resist the acid. Minerals which yield gelatinous silica are marked G, and those which give slimy or pulverulent silica, S.

* *Journal für prakt. Chemie.* Vol. XCII. p. 175.

BEHAVIOR OF CERTAIN SILICATES WITH HCL AND WITH CITRIC ACID.

MINERAL.	HC	$\bar{C}$	MINERAL.	HCl	$\bar{C}$
Wollastonite	1G	1S	Rhodonite.....	1	1
Chrysolite	1G	2	Natrolite	1G	1G
Olivine.....	1G	3	Analcite.....	1S	1S
Willemite	1G	1G	Chabazite.....	1S	1S
Wernerite	1-2	3	Stilbite.....	1	2
Chondrodite.....	1G	1-2 G	Serpentine.....	1S	1S
Datolite.....	1G	1G	Retinalite.....	1S	1S
Pectolite	1G	1G	Chrysotile.....	1S	2-3
Chrysocolla.....	1	1	Deweylite	1S	1S
Calamine	1G	1G	Talc.....	3	3
Prehnite	1	2	Epidote.....	3	3
Apophyllite.....	1S	2S	Orthoclase.....	3	3

In order to ascertain approximately the comparative decomposing power of the commoner organic acids with silicates, two which yield readily to citric acid and one which is attacked with difficulty were selected for treatment. The following are the results:

	Calamine.	Natrolite.	Prehnite.
Citric Acid	1G	1G	2
Tartaric "	1G	1G	3
Oxalic "	2	3	3
Formic "	1G*	1	3
Malic "	1G	1G	3
Acetic "	1G	2-3	3

* Very soluble.

Since calamine and willemite are sometimes distinguished by their behavior with acetic acid—the former gelatinizing and the latter giving slimy silica—it was thought of interest to examine their behavior with other organic acids. The results are given below:

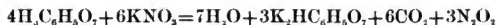
	Calamine.	Willemite.
Citric Acid	1G	1G
Tartaric "	1G	1*
Oxalic "	2	2
Formic "	1G	1S
Malic "	1G	1
Acetic "	1G	1S

* Solution becomes very milky in appearance.

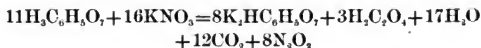
DECOMPOSITION OF MINERALS BY ORGANIC ACIDS AND
OXIDIZING AGENTS.

18. Desirous of extending the use of organic acids in attacking minerals, we tried the effect of adding oxidizing agents to the solution of the acid; the results were satisfactory and prompted the following investigation:

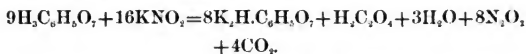
When potassium, sodium, or ammonium nitrate is added to a boiling solution of citric acid, on reaching a certain degree of concentration nitric acid is set free, and this immediately reacts upon the organic acid, decomposing it with evolution of gases. These gases proved on examination to consist of nitric oxide and carbonic anhydride; whether carbonic oxide is present was not determined. The reaction which takes place is very complex; it may possibly be expressed thus:—



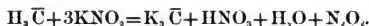
or admitting the formation of oxalic acid,* we may write:—



Potassium nitrite also decomposes citric acid in a somewhat similar manner, the action beginning in the cold and continuing with violence and a rise of temperature. The reaction may be expressed as follows:—



Or, abbreviating and disregarding the decomposition of the organic acid, we may have

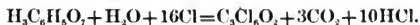


The nitric acid being then in a nascent condition, is prepared to effect oxidation in a most powerful manner.

When chlorate of potassium is substituted for the nitrate or nitrite, the decomposition begins on boiling down the solution to small bulk, and proceeds very vigorously, the carbonic

* *Watts' Dictionary*, I. 996.

anhydride disengaged being accompanied by a gas having an excessively irritating odor and exciting tears. This peculiar substance is probably the same as that obtained in 1847 by Plantamour,* by the action of chlorine on sodium citrate, and which was subsequently studied by Laurent, by Staedler, and by Cloez.† The latter showed the irritating body to be perchlorinated acetate of methyl, $C_3Cl_6O_7$, and explains its formation as follows:‡



Precisely how the action proceeds with potassium chlorate and citric acid we have not determined; it is undoubtedly more complex than even the following equation indicates:—

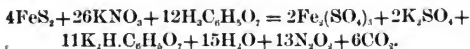


Tartaric acid behaves exactly like citric acid with the nitrate and the chlorate. Oxalic acid decomposes them in very concentrated solutions and attacks the nitrite very actively, probably in the following manner:



Acetic and formic acids do not decompose the nitrate nor the nitrite.

19. These interesting reactions enable us to attack many mineral sulphides with the greatest ease. With potassium nitrite and citric acid, they are decomposed in the cold; with the nitrate and chlorate, only on boiling. Pyrites, for example, in fine powder, is very quickly decomposed by these powerful agents, and completely dissolved, save a little sulphur. The solution contains ferric sulphate and hydropotassium citrate, while both nitric oxide and carbonic anhydride are evolved abundantly; the reaction then may be formulated as follows:—



* Berzelius, Jahresbericht. Vol. xxvi, p. 428.

† *Annals de Chimie et de Physique*, (3) xvii. 297 and 311.

‡ Cf. Watts' Dictionary, I, 996.

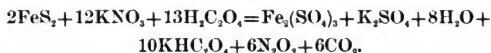
Of the eighteen sulphides selected for examination, all but two, molybdenite and cinnabar, are readily decomposed by heating with citric acid and potassium nitrate; stibnite and bournonite yield clear and colorless solutions; argentite and galenite, turbid and colorless solutions; bornite, sphalerite, chalcocite, pyrrhotite, niccolite, smaltite, pyrite, chalcopyrite, ullmannite, marcasite, arsenopyrite, and tetrahedrite give colored solutions not particularly characteristic. The copper minerals, heated with a large proportion of the organic acid, give precipitates of red oxide of copper. The sulphur in these minerals is not completely oxidized by the potassium nitrate and a part floats in the solutions.

Parallel experiments with citric acid and potassium chlorate gave similar results, but the action of the chlorate is slower. Tartaric acid may be substituted for citric, and appears to differ little in its solvent power.

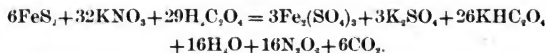
20. Although oxalic acid decomposes potassium nitrate, only in the most concentrated solutions, yet the presence of an oxidizable body like pyrites incites a reaction which effects complete decomposition of the sulphide, precisely as with citric acid. Potassium nitrate and oxalic acid heated together give the following reaction:—



and on the addition of pyrites we have:



Since, however, the nitric oxide is evidently evolved in much greater proportion than the carbonic anhydride, the following equation probably expresses the actual reaction with greater accuracy:—



To decompose sulphides with oxalic acid and potassium nitrate, the best results are secured by boiling the two reagents together for a short time and then adding the finely pulverized

mineral; a violent action sets in immediately. In studying the rationale of the above-named decompositions, we discovered that many sulphides are attacked by an aqueous solution of potassium nitrate (and nitrite) without the addition of acid; this unexpected result explains satisfactorily the violence of the decomposition of the sulphides by the mixture of reagents, many forces being simultaneously brought into play; the organic acid, while able to decompose the potassium nitrate alone, acts at the same time as a solvent of the products resulting from the decomposition of the sulphide by the nitrate.

This explains also the fact that the comparatively weak acids—malic, acetic, and formic—which do not of themselves decompose potassium nitrate, are able to dissolve the sulphides in the presence of the latter reagents. We are now investigating the behavior of certain minerals with these and other saline solutions, and hope to present the results in a future paper.

We have applied this method of attack to several other classes of minerals, but without much advantage. The oxides of iron, magnetite and hematite, as well as franklinite and chromite, resist the combined action of the mixed reagents. The decomposition of silicates is not notably facilitated. Limonite is feebly attacked. Uraninite, however, dissolves completely and rapidly in this mixture of reagents.

The remarkable solvent power of a mixture of nitrate of potassium and citric acid is further demonstrated by the fact that metallic copper, silver, lead, tin, bismuth, and antimony, as well as magnesium, iron, and zinc, dissolve therein with more or less rapidity.

Aluminium resists this mixture of reagents:—the alchemists' dream of an *alcahest*, or universal solvent, is therefore only partly realized.

DECOMPOSITION OF SILICATES BY ORGANIC ACIDS AND AMMONIUM FLUORIDE.

21. A hot concentrated solution of citric acid decomposes ammonium fluoride, setting hydrofluoric acid free; and if

silicates are present, many of them dissolve with great facility. Those minerals which were hardly attacked by citric acid alone, viz.: olivine, wernerite, chondrodite, and prehnite, together with the following not previously examined, orthoclase, albite, labradorite, augite, diopside, hornblende, almandite, spodumene, kyanite, talc, and epidote, are more or less readily decomposed. Of the latter, albite, labradorite, and augite, dissolve quite freely, while epidote appears to be slightly attacked by citric acid alone.

That this method of attack must be conducted in platinum vessels, goes without saying; the silicon evolved as a fluoride may be detected by suspending a moistened glass rod in the vapors, causing a gelatinous precipitate. To obtain affirmative results, it is essential that the silicates should be in very fine powder; the common micas, muscovite and biotite, which are obtained in pulverulent form with great difficulty, appear to resist these reagents; and ripidolite is but slightly attacked, perhaps for the same reason.

Tourmaline decidedly resists the action of these reagents, as well as the fluorides, cryolite, and fluorite. Samarskite is not attacked.

It is hardly to be expected that this method of examining minerals will be serviceable in field work, but it may prove applicable to quantitative analysis.

SUMMARY OF RESULTS.

22. The results of this investigation establish the hitherto unrecorded fact that organic acids not only decompose a considerable number of minerals belonging to various groups, but they also possess a remarkable selective power as regards the degree of this decomposition; to make this selective property of citric acid evident, and at the same time to present a condensed recapitulation of its action on the ninety minerals examined, we have drawn up the annexed table (p. 30). This table shows that citric acid alone divides minerals into eight groups: A, those which dissolve in the cold without evolution of gas; B, those which dissolve in the cold with liberation of carbonic anhydride; C, those which are decomposed in the

cold with liberation of sulphureted hydrogen; D, those which dissolve in the hot acid without evolution of gas; E, those which dissolve in the hot acid with liberation of carbonic anhydride; F, those which dissolve in the boiling acid with liberation of sulphureted hydrogen; G, those which are decomposed on boiling, with formation of gelatinous silica; H, those which are decomposed on boiling, with separation of silica in a slimy or a pulverulent form. To these eight groups we may add three more: I, those which are decomposed by boiling with citric acid and potassium nitrate; K, those which are decomposed by heating with citric acid and ammonium fluoride; and L, those which are not attacked by any of the preceding methods.

Under E fall five minerals, hausmannite, manganite, psilomelane, pyrolusite, and wad, which dissolve rapidly in hot citric acid and decompose it with liberation of carbonic anhydride. Advantage is taken of this reaction in the quantitative analysis of manganese dioxides.

Notwithstanding the sharpness of the reactions by which many of the minerals are characterized, we do not regard the annexed table as a scheme for their determination, but merely as a general view of their behavior. The special cases in which minerals may be distinguished have been mentioned previously.

Under L are found thirteen of the ninety minerals examined; perhaps some of these will yield to these methods of attack by varying slightly the means of application. It is possible also that some of them may be decomposed by heating with citric acid solution in sealed tubes under pressure; but this process of course is not applicable to field work.

TABLE SHOWING THE BEHAVIOR OF CERTAIN MINERALS WITH CITRIC ACID, ALONE AND WITH REAGENTS.

DECOMPOSED (IN FINE POWDER) BY A SOLUTION OF CITRIC ACID.								I.	K.
IN THE COLD.				ON BOILING.				Decomposed by boiling with C + KNO ₃ .	Decomposed by heating with C + NH ₄ F.
A. Without evolution of gas.	B. With liberation of CO ₂ .	C. With liberation of H ₂ S.	D. Without evolution of gas.	E. With liberation of CO ₂ .	F. With liberation of H ₂ S.	G. With formation of a jelly (SiO ₂).	H. With separation of SiO ₂ .		
Brucite. Angelite. Pyromorphite.* Vivianite.	Calcite. Dolomite.* Ankerite.* Gurcharite. Stichtonite.* Willemite.* Siderite.* Barroisite.* Pyrochalcite.* Malachite. Azurite.*	Stibnite. Galena.* Sphalerite. Pyrrhotite.	Zincite. Gypsum.* Apatite.* Cuprite. Limonite.*	Magnesite. Siderite.* Pyrrhotite.† Wad.† Wassmannite.† Magnesite.† Palladumchloride.†	Bornite. Bourbonite.*	Willemite. Dolomite. Pecolite. Cassiterite. Natrolite.	Wollastonite. Chrysotile.* Chondrodite.* Pyrochalcite.* Pseudomalachite.* Apoehydrate.* Rhodonite. Analcite. Chabasite. Stibite. Serpentine.* Chrysotile.* Retinalite. Deweyite.	Argentite. Chalcocite. Pyrite. Muscovite. Nicalite. Smaltite. Chalcocyanite. Ullmannite. Arenigite. Tetrahedrite. Uraninite.	Olivine. Wernerite. Orthoclase. Albite. Labradorite. Augite. Diopside. Hornblende. Kyanite. Tremolite.* Scedunone.* Almandine. Epidote.
			and those in A.	and those in B.	and those in C.			and those in F. and C.	and those in G. and H.

I.—Minerals not decomposed by the above reagents: Molybdenite, cinnabar; magnesite, hematite, franklinite; cryolite, fluorite; samarskite; muscovite, biotite, ripidolite, and tourmaline.

* Feebly attacked.

N. B.—The gases evolved are examined with acetate of lead test-paper; the solutions with appropriate reagents. † The CO₂ evolved is derived from the citric acid.

23. The applications of the methods of examining minerals detailed in the preceding pages are, we believe, numerous and important. Many of the reactions are simple, quickly applied, characteristic, and sensitive; they may be used, as we have seen, in distinguishing minerals nearly related, and probably in separating minerals mingled in one specimen. The methods will in all probability find useful application in quantitative analysis, a point which we propose to test at some future time. We have already employed a solution of citric acid in the analysis of limestones, for the determination of carbonic anhydride by loss. The evolution of gas proceeds regularly and the limestone is completely decomposed; citric acid possesses an advantage over hydrochloric acid in being non-volatile. Experiments to test the accuracy of the method were made with well-dried precipitated carbonate of calcium, and gave results differing by two or three tenths from the theoretical percentage.

By using the non-volatile organic acids in microscopic work whenever applicable, possible injury to the metallic mountings may be avoided, and in certain cases characteristic phenomena may be observed.

The importance of the application of these methods to the examination of minerals and rocks *in the field* is evident. The testimony of various persons as to the practicability of blow-pipe work and chemical work in the field differs greatly, some claiming that it is valuable and easily accomplished, and others that it is altogether impracticable. Professor Geikie, Director of the Geological Survey of Scotland, mentions as a valuable addition to the geologist's outfit, "a small bottle of weak hydrochloric acid, carried in a protecting wooden box or case, of use for testing carbonates;" and he quotes Sir William Logan as employing acid to test the material adhering to a "limestone spear," with which the underlying strata can be probed.*

We propose, therefore, the substitution of a stout paste-board box, containing solid citric (or tartaric) acid, for the

* Science Lectures at South Kensington: Outlines of Field Geology. 1877.

usual glass bottle of liquid hydrochloric acid, and the addition of potassium nitrite to the usual list of dry reagents contained in portable blow-pipe cases. Since citric acid solution decomposes potassium nitrite in the cold, we can carry nitric acid practically in a solid form; hydropotassium sulphate, already in use, furnishes sulphuric acid in a solid state; and it only remains, therefore, to provide for hydrochloric acid. Our experiments have as yet failed to solve this problem directly; ammonium, sodium, and potassium chlorides appear to resist the action of the organic acids. Iodine, on the other hand, while much less powerful than chlorine, possesses similar properties, and will form a valuable addition to the list of dry reagents; in aqueous solution it attacks many sulphides, and gives rise to characteristic phenomena. Iodine water was employed as early as 1858, by Professor Henry Wurtz, to separate pyrrhotite from pyrite;* but he did not extend its use to the determination of minerals, a question which we are now engaged in studying, and which has already yielded very interesting results.

Citric acid, potassium nitrite, and iodine, then, added to the reagents in common use,—borax, sodium-carbonate, potassium cyanide, ammonio-sodium phosphate, test-lead, tin, and an assortment of test-papers, including acetate of lead paper, together with as many of the solid reagents used in solutions as space will admit, would complete the outfit of *dry reagents* for *wet analysis* and for blow-piping.

A pocket case, made of lacquered tin, 20 cm. long, 5 cm. wide, and 2.3 cm. deep, containing pasteboard boxes (pill-boxes) of citric acid, potassium nitrate, dried borax, and sodium carbonate, together with a few simple requisites for blow-pipe work, has been used by the writer in short mineralogical excursions with great satisfaction. To carry on the examination with solutions, we are also provided with a pasteboard case, cylindrical in form, 14 cm. long, containing five stout test-tubes, fitting one within another, like a nest of beakers; the interior tube is open at both ends, a cork inserted

* American Journal of Science, (2) xvi, 190.

tightly in the centre of the tube divides it into two compartments, one of which is filled with pulverized citric acid and the other with potassium nitrite, to be subsequently dissolved in water obtained in the field. This simple arrangement, greatly economizing space, will naturally suggest itself to all working mineralogists, and would scarcely be worth mentioning were not wet analyses commonly regarded as impracticable in field work.

In proposing the use of organic acids in this connection, we are aware that they already occupy a place in the lists of "Special Reagents" contained in the larger treatises on Blow-pipe Analysis. Plattner* mentions tartaric acid, but limits its use to the separation of yttria and zirconia (by ammonium sulphide); and he names oxalic acid as employed in the precipitation of lime and in the separation of iron and uranium from yttrium, cerium, and lanthanum. To remove the organic acids from this restricted use, and to accord to them a more important position in the list of reagents, is our aim.

APPLICATION TO GEOLOGICAL PHENOMENA.

24. This newly developed power of the organic acids has undoubtedly an important bearing on the chemistry of geological changes: organic acids, resulting from the decomposition of vegetable and animal matter, demand recognition as powerful agents in the work of disintegration and consolidation.

Many of the results attributed to the imperfectly studied bodies, geic acid, $C_{20}H_{12}O_7$, humic acid, $C_{20}H_{12}O_6$, and ulmic acid, $C_{20}H_{14}O_6$ †—as well as the oxidation products, crenic and apocrenic acids—are perhaps the silent work of a higher class of organic acids.

That such acids constitute ingredients of the soil, is well established: "When the leaves of beets, tobacco, and other large-leaved plants, fall upon the soil, oxalic and malic acids

* Plattner's Manual, translated by Prof. H. B. Cornwall, third edition, pp. 53 and 54. 1875.

† Mulder, Ann. Chem. Pharm., xxxvi. 243, 1840. Detmer ascribes to humic acid the formula $C_{40}H_{14}O_{27}$, and regards humic and ulmic acid as identical in composition. Cf. Watts' Dict., II Suppl., 648.

may pass into it in considerable quantity. Falling fruits may give it citric, malic, and tartaric acids." "Formic, propionic, acetic, and butyric acids, or rather their salts, have been detected by Jongbloed and others in garden-earth. The latter are common products of fermentation, a process that goes on in the juices of plants that have become a part of the soil or of a compost."*

How far these organic bodies assist in disintegrating rock material is largely a matter of conjecture; that they do exert considerable influence may be concluded from the existence in the soil of the ulmates, humates, apocrenates, and crenates of potash, soda, ammonia, lime, magnesia, iron, manganese, and alumina. We have, moreover, numerous instances of minerals containing organic acids in combination:

Berzelius and other chemists have remarked the occurrence in marshes of compounds of iron and organic acids, of undetermined composition. Prof. T. Sterry Hunt† describes limonites containing from 12.5 to 15 per cent. of humic acids; Dr. George A. Koenig,‡ in an investigation of the cause of the deep green coloration of amazon-stone from Pike's Peak, concludes that the coloring matter consists of some compound of iron with an organic acid, the nature of which he has not yet determined. Dr. Gideon E. Moore, in a paper on Cryptocallite, recently presented to the New York Academy of Sciences, refers to moresnetite containing iron combined with some organic acid. Forster§ conjectures that the color of smoky quartz is due to the presence of an organic substance containing carbon and nitrogen.

To these scattered notices may be added the small number of minerals, mentioned in Dana's System of Mineralogy, of which organic acids form constituents:

Whevellite, calcium oxalate, occurring in small crystals on calcite.

Thierschite, another calcium oxalate, forming an opaline incrustation on the marble of the Parthenon at Athens. Its origin is attributed to the action of vegetation on marble.

* Prof. S. W. Johnson in "How Crops Feed." New York, 1870.

† Geol. Canada, 1863, 510.

‡ Proc. Acad. Nat. Sci., Philadelphia, 1876, p. 155.

§ Pogg. Ann., cxliii, 173.

Humboldtine, hydrous ferrous oxalate, forming an incrustation on brown coal.

Succinite, or amber, containing $2\frac{1}{2}$ to 6 per cent. succinic acid.

Mellite, or hydrous mellitate of alumina, containing over 40 per cent. of the organic acid.

Pigotite, a salt of alumina and mudescous acid (Johnston). Formed on granite by the action of wet vegetation.

To these belong also the peculiar minerals grouped by Dana under the name Acid Hydrocarbons, found in peat-bogs and in brown coal, and containing the ill-defined bodies, geoceric, georetinic, and butyro-limnodic acids.

25. The manner in which silicates are decomposed and silica rendered soluble for the use of the vegetable world, has been a subject of much investigation. Friedel and Crafts,* in their remarkable researches on the ethers of silicic acid, and Friedel and Ladenburg,† in a paper on silico-propionic acid, have given a new insight into the functions of silica and its transformations in the organic kingdom. The reading of the latter paper before the French Academy of Sciences, June 27, 1870, excited a lively interest; the authors describe silico-propionic acid, $\text{Si C}_2\text{H}_5\text{O}_2\text{H}$, as a white amorphous body closely resembling silica, insoluble in water, and soluble in hot concentrated potassium hydrate. This communication drew from M. Paul Thénard‡ a remarkable announcement with respect to the solvent power of nitro-humic acid § on silica; he stated in substance that the dark-colored acids of the soil consist of a mixture of acids of the humic and nitro-humic series, which contain a notable amount of silica, the amount varying from 7.5 to 24 per cent.; and he conjectures that acids of the "nitro-humic series form spontaneously in the soil at the expense of the humic acid, the ammonia of rain-water, nitrogen of the air, and of the silica pre-existing in the soil."

Dr. J. S. Newberry, in a private communication to the writer, describes the peculiar manner in which quartz pebbles

* Bull. soc. chim., V, 174, 238 (1863).

† Comptes Rendus, LXX, 1407.

‡ Comptes Rendus, LXX, 1412.

§ In translating "*acide azhumique*" by the term "nitro-humic acid," we follow custom, but we are of the opinion that "azo-humic acid" would be more correct, since the word "nitro-humic" implies the existence of a "nitro" radical, NO_2 .

found at Keyport, N. J., in a clay very rich in carbonaceous matters, are eroded. All the sharp angles on these pebbles have been rounded, and the surfaces are more or less deeply pitted, as if by some solvent. He has also observed other phenomena of similar character, which he conjectures should be ascribed to the action of organic acids.

These references would be incomplete without mention of the generalizations of Prof. Henry Wurtz, whose "Scheme of the Geogonic Migrations of Silica throughout the Kingdoms of Life,"* shows thoughtful study and novel views.

Taken as a whole, the information respecting the part played by organic acids in the changes taking place on the earth's surface, is but small: are we not justified in the belief that some of the reactions disclosed by our researches may in the hands of chemical geologists furnish material for generalizations of no small value?

Finally, we are conscious of having treated but a very small number of minerals, compared with those which remain to be studied; our aim has been to place the methods of examination on record, rather than to exhaust the resources of mineralogy.

We take pleasure in acknowledging the services of Mr. Edward W. Martin, a student in the Chemical Course at the School of Mines, who has kindly assisted us in a portion of these researches.

*School of Mines, Columbia College,
New York.*

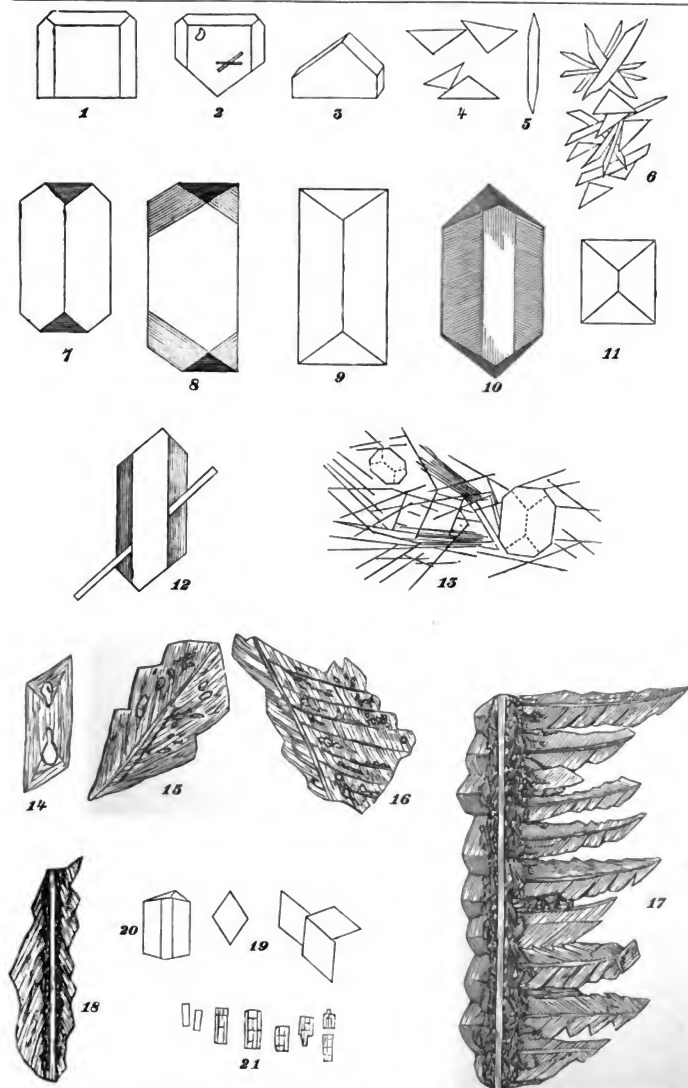
* American Chemist, I, 206.

EXPLANATION OF PLATE I.

Micro-crystalline Precipitates, cf. pp. 14-18.

Figs. 1 to 6.....	Tartaric acid.
Figs. 7 to 12.....	Hydro-calcium tartrate.
Fig. 13.....	Hydro-barium tartrate.
Figs. 14 to 16.....	Hydro-barium oxalate, from witherite.
Figs. 17, 18.....	The same, from baryto-calcite.
Figs. 19, 20.....	Hydro-strontium oxalate.
Fig. 21.....	Ferrous oxalate.

NOTE.—These crystals vary in size, according to temperature and time of formation, and were not drawn by exact measurement. For the large crystals, figs. 14 to 18, a $1\frac{1}{2}$ inch objective was used; figs. 19, 20, and 21, required a $\frac{1}{2}$; the others were easily seen with a $\frac{1}{4}$.



Bolton, H. C.

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APPLICATION OF ORGANIC ACIDS
TO THE
Examination of Minerals,

[SECOND PAPER.]

By H. CARRINGTON BOLTON, Ph.D.

Professor of Chemistry in Trinity College, Hartford, Conn.

[FROM THE ANNALS OF THE N. Y. ACADEMY OF SCIENCES.
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With compliments of

H. Carrington Bolton, Ph. D.

TRINITY COLLEGE,

Hartford, Conn.

1881, Jan 7,

I.—Application of Organic Acids to the Examination of Minerals.

[Second Paper.]

BY H. CARRINGTON BOLTON, PH. D.

Read January 5th, 1880.

26. The behavior of minerals with organic acids has already formed the subject-matter of two papers read before the Academy in 1877 and 1878, and we now present the results of a continuation of our researches.

In our first paper* we described several new methods of attacking minerals, and their application to ninety-five specimens; in the following pages we extend the investigation to one hundred and six additional minerals. These methods of decomposition were as follows :—

- 1st. Treatment with a cold saturated solution of citric acid.
- 2d. Treatment with a boiling solution of the same.
- 3d. Heating with a saturated solution of citric acid to which sodium nitrate is added.
- 4th. Heating with a saturated solution of citric acid to which ammonium fluoride is added.

And in a second paper, under another title,† we added a fifth reaction :—

- 5th. Heating with a concentrated solution of citric acid to which potassium iodide is added.

* *Annals N. Y. Acad. Sci.*, Vol. I, p. 1.

† *Behavior of Natural Sulphides with Iodine and other Reagents. Annals N. Y. Acad. Sci.*, Vol. I, p. 153.

Similar reactions with oxalic, tartaric, acetic, and other organic acids, were described in the first paper, but preference is given to citric acid on account of its greater solvent power.

Minerals belonging to several groups were submitted to these processes, and gave phenomena which may be summarized as follows :

- 1st. More or less complete decomposition and solution of oxides, phosphates, etc., without formation of precipitates or liberation of gases.
- 2d. Complete solution of carbonates with evolution of carbonic anhydride.
- 3d. Decomposition of sulphides with evolution of sulphuretted hydrogen.
- 4th. Decomposition of sulphides with oxidation of the sulphur.
- 5th. More or less perfect decomposition of silicates with separation of either slimy or gelatinous silica.
- 6th. Decomposition of certain species by reagents forming characteristic precipitates.
- 7th. Wholly negative action.

These facts demonstrated that citric acid has a power of decomposing minerals little less than that possessed by hydrochloric acid, and that this very difference in degree gives the organic acid an advantage over the mineral acid in the determination of species.

27. This peculiar selective power of citric acid rendered desirable a further study of its action on a larger number of minerals; the following list contains the names of the species which have since been submitted to the process named, together with their formulæ, condition, and locality.

Within the groups,—I, Sulphides, Arsenides, Tellurides, etc., —II, Oxides,—III, Silicates, and—IV, Sundries, the minerals are arranged in the order in which they are given in Dana's System of Mineralogy.

We desire to express our thanks to Prof. Thomas Egleston, of the School of Mines, Columbia College, who has again placed us under obligations by supplying many of the rarer minerals.

I. SULPHIDES, ARSENIDES, ETC.

MINERAL.	FORMULA.	DESCRIPTION.	LOCALITY.
Sulphur.....	S ₂	massive	Humboldt, Nev.
Realgar.....	As ₂ S	crystalline.....	Hungary.
Orpiment.....	As ₂ S ₃	crystals	Hungary.
Bismuthinite.....	Bi ₂ S ₃	in quartz.....	Clear Creek, Col.
Domeykite.....	Cu ₂ As ₂	massive	Chili, S. A.
Clausthalite.....	PbSe	—	Tilkerode, Hartz.
Alabandite.....	MnS	crystalline.....	Mexico.
Hessite.....	Ag ₂ Te	—	Boulder, Col.
Tiemaninite.....	HgSe	incrusting.....	Clausthal, Hartz.
Millerite.....	NiS	crystalline.....	Lancaster Co., Pa.
Linnaeite.....	2 CoS + CoS ₂	crystals.....	Mitsen, Prussia.
Cobalite.....	Co(S, As) ₂	grains	Tunaberg, Sweden.
Leucopyrite.....	FeAs ₂	massive	Breitenbrunn, Saxony.
Nagayagite.....	2 (Pb, Au) + 3 (Te, Sb, S)	foliated	Austria.
Covellite.....	CuS ₂	massive	Germany.
Berthierite.....	FeS + Sb ₂ S ₃	crystalline.....	Braunsdorf, Saxony.
Jamesonite.....	2 (Pb, Fe)S + Sb ₂ S ₃	fibrous.....	—
Pyrrargyrite.....	3 AgS + Sb ₂ S ₃	massive.....	Chili.
Proustite.....	3 AgS + As ₂ S ₃	massive	Chili.

Boulangerite.....	$3 \text{ Pb S} + \text{Sb}_2 \text{ S}_3$	massive.....
Tennantite.....	$4 (\text{Cu Fe}) \text{ S} + \text{As}_2 \text{ S}_3$	crystalline.....Cornwall, England.
Stephanite.....	$5 \text{ Ag S} + \text{Sb}_2 \text{ S}_3$	massive.....Mexico.
Polylbasite.....	$9 (\text{Ag Cu}) \text{ S} + (\text{Sb, As})_2 \text{ S}_3$	massive.....
Enargite.....	$3 \text{ CuS} + \text{As}_2 \text{ S}_3$	massive.....Gilpin Co., Colorado.
Kermesite.....	$2 \text{ Sb S}_2 + \text{Sb O}_3$	crystalline.....Braunsdorff, Saxony.

II. OXIDES.

MINERAL.	FORMULA.	DESCRIPTION.	LOCALITY.
Melacconite.....	Cu O	massive.....	Copper Harbor, L. S.
Corundum.....	$\text{Al}_2 \text{ O}_3$	white, massive.....	North Carolina.
Menacaunite.....	$(\text{Ti, Fe})_2 \text{ O}_3$	crystals.....	Ilmeu Mts., Russia.
Washingtonite.....	$(\text{Ti, Fe})_2 \text{ O}_3$	crystals.....	Litchfield, Conn.
Spinel.....	Mg Al	crystals.....	Franklin, N. J.
Chrysoberyl.....	Be Al	crystals.....	Brazil.
Cassiterite.....	Sn	crystals.....	Cornwall, England.
Rutile.....	Ti	crystals.....	York, Pa.
Braunite.....	$2 \text{ Mn, Mn} + \text{Mn Si}$	crystalline.....	Thuringia.
Goethite.....	Fe H	crystalline.....	Easton, Pa.
Gummite.....	$(\text{V Fe}) + \text{H}_2$	amorphous.....	North Carolina.

Quartz.....	Si	crystals.....Conn.
Hyalite....	Si + aq.	maumillary.....Waltch, Bohemia.

III. SILICATES.

MINERAL.	FORMULA.	DESCRIPTION.	LOCALITY.
Enstatite.....	Mg Si	massive,...	North Carolina.
Hypersthene.....	(Mg Fe) Si	massive.....	Labrador.
Petalite.....	($\frac{1}{2}$ R ₂ + $\frac{1}{2}$ R) Si ₂ + 3 Si	massive.....	Sweden.
Pargasite.....	(R ₂ , R) (Si Al $\frac{1}{2}$)	massive....	Diana, N. Y.
Actinolite.....	(Ca Mg Fe) Si	crystals.....	Oxbow, N. Y.
Asbestos.....	(R ₂ , R) (Si Al $\frac{1}{2}$)	silky fibrous.....	—
Beryl.....	($\frac{1}{2}$ Be ₂ + Al $\frac{1}{2}$) Si ₂	transp. crystals.....	Brazil.
Tephroite.....	Mn ₂ Si	massive.....	Franklin, N. J.
Pyrope.....	($\frac{1}{2}$ Mg, Ca, Fe, Mn) ₂ + $\frac{1}{2}$ Al $\frac{1}{2}$, Si ₂	crystals.....	Bohemia.
Colophonite.....	($\frac{1}{2}$ R ₂ + $\frac{1}{2}$ R), Si ₂	crystals.....	Willsborough, N. Y.
Zircon.....	Zr Si	crystals.....	North Carolina.
Veauvanite.....	($\frac{1}{2}$ R ₂ + $\frac{1}{2}$ R) Si ₂	crystals.....	Moldavia.
Allanite.....	Si, Al, Fe, Mn, Ca, La, Dd, Y, H	partially decomposed...	Virginia.
Zoisite.....	($\frac{1}{2}$ Ca ₂ + $\frac{1}{2}$ Al $\frac{1}{2}$) Si ₂	massive.....	Conway, Mass.
Ilvaite.....	($\frac{1}{2}$ R ³ + $\frac{1}{2}$ R) Si ₂	massive.....	Hartz Mts.

Idite	$\text{Si, } \ddot{\text{Al}}, \text{Fe, Mg}$	translucent.....Fioulad.
Phlogopite	$(\frac{1}{2}\text{R}_2 + \frac{1}{11}\text{R})_2 \text{Si}_2$	milceous Montvillia, N. J.
Lepidolite	$\text{Si, } \ddot{\text{Al}}, \text{Fe, Li, K, F}$	milceous.....Paris, Maine.
Nephelite	$(\text{R}_2 + \frac{1}{2}\text{Al})_2 \text{Si}_2 + \frac{1}{2}\text{Si}$	mixed with biotite....Vesuvius.
Lapis lazuli	$\text{Si, } \ddot{\text{Al}}, \text{Ca, Na, S}$	massive, ...Brazil.
Leucite	$\text{K Si} + \ddot{\text{Al}}_2 \text{Si}_2$	crystals.....Vesuvius.
Anorthite	$(\frac{1}{2}\text{R}_2 + \frac{1}{2}\text{Al})_2 \text{Si}_2$	massive.....Tunaberg, Sweden.
Oligoclase	$(\frac{1}{2}\text{Na, Ca})_2 + \frac{1}{2}\text{Al})_2 \text{Si}_2 + 3\frac{1}{2}\text{Si}$	massive.....Chester Co., Pa.
Andalusite, ...	$\ddot{\text{Al}} \text{Si}$	crystals.....Bavaria.
Fibrolite	$\ddot{\text{Al}} \text{Si}$	crystalline.....Wilmingon, Del.
Topaz.	$\ddot{\text{Al}} \text{Si}$	crystals.....Brazil.
Titanite.....	$(\text{Ca} + \text{Ti}) \text{Si}$	crystals.....Diana, N. Y.
Staurolite	$(\frac{1}{2}\text{R}_2 + \frac{1}{2}\text{Al})_2 \text{Si}_2$	crystals....Franconia, N. H.
Laumontite	$\text{Si, } \ddot{\text{Al}}, \text{Ca, H}$	crystals.....Peter's Point, N. S.
Thomsonite.....	$2 \text{Si, } \ddot{\text{Al}} (\frac{1}{2}\text{Ca} + \frac{1}{2}\text{Na}), 2\frac{1}{2}\text{H}$	crystalline.....Renfrewshire, Scotland.
Mesolite.....	$3 \text{Si, } \ddot{\text{Al}} (\frac{1}{2}\text{Ca} + \frac{1}{2}\text{Na}) + 3 \text{H}$	crystalline.....Peter's Point, N. S.
Herschelite	$\text{Si, } \ddot{\text{Al}}, \text{Ca, Na, K, H}$	———— Cyclops, Catania.
Heulandite.....	$6 \text{Si, } \ddot{\text{Al}}, \text{Ca, 5H}$	red, crystalline.....Fassathal, Tyrol.
Bowenite.....	$2 \text{Mg Si} + \text{Mg H}_2$	amorphous.....Smithfield, R. I.
Bastite.....	————	massive.....Germany.
Genthite	$(\frac{1}{2} (\text{Ni, Mg}) + \frac{1}{2}\text{H}_2 \text{Si} + \frac{1}{2}\text{H}$	amorphous.....North Carolina.

Kaolin.....	$\ddot{\text{Al}} \ddot{\text{Si}}_2 + 2\text{H}$	pulverulent.....Rossville, Staten Island.
Gieseckite.....	$\ddot{\text{Si}}, \ddot{\text{Al}}, \ddot{\text{Fe}}, \ddot{\text{Mg}}, \ddot{\text{Ca}}, \ddot{\text{Na}}, \ddot{\text{H}}$	massive.....St. Lawrence Co., N. Y.
Jefferisite.....	$(\ddot{\text{R}}_2 + \ddot{\text{H}})_2 + \ddot{\text{Si}}_2 + 3\text{H}$	micaceous.....West Chester, Pa.
Prochlorite.....	$(\ddot{\text{I}} (\ddot{\text{Mg}} \ddot{\text{Fe}})_2 + \frac{1}{2}\ddot{\text{H}}) \ddot{\text{Si}} + 4\text{H}$	crystalline.....New Bedford, Mass.
Masonite.....	$(\ddot{\text{I}} (\ddot{\text{Fe}} \ddot{\text{Mg}})_2 + \frac{1}{2}\ddot{\text{H}})_2 \ddot{\text{Si}}_2 + 3\text{H}$	massive.....Natic, R. I.

IV. SUNDRY MINERALS.

MINERAL.	FORMULA.	DESCRIPTION.	LOCALITY.
Atacamite.....	$3 \ddot{\text{Cu}} \ddot{\text{H}} + \ddot{\text{Cu}} \ddot{\text{Cl}} \ddot{\text{H}}$	granular.....Chili.	
Columbite.....	$(\ddot{\text{Fe}} \ddot{\text{Mn}}) (\ddot{\text{Cb}} \ddot{\text{Tb}})$	crystalline.....Haddam, Conn.	
Mimetite.....	$3 \ddot{\text{Pb}} \ddot{\text{As}} + \ddot{\text{Pb}} \ddot{\text{Cl}}$	crystals.....Bohemia.	
Triphylite.....	$(\ddot{\text{Fe}} \ddot{\text{Mn}} \ddot{\text{Li}})_2 \ddot{\text{P}}$	massive.....Grafton, N. H.	
Triplite.....	$\ddot{\text{R}}_2 \ddot{\text{P}} + \ddot{\text{R}} \ddot{\text{Fl}}$	massive.....Limoges, France.	
Libethenite.....	$\ddot{\text{Cu}}, \ddot{\text{P}} + \ddot{\text{H}}$	crystalline.....Cornwall, England.	
Olivinite.....	$\ddot{\text{Cu}}_2 (\ddot{\text{As}} \ddot{\text{P}}) + \ddot{\text{Cu}} \ddot{\text{H}}$	crystalline.....Cornwall, England.	
Pseudomalachite.....	$\ddot{\text{Cu}}, \ddot{\text{P}} + 3 \text{H}$	massive-granular.....Copperopolis, Utah.	
Wavellite.....	$\ddot{\text{Al}} \ddot{\text{P}}, \ddot{\text{H}}$	crystalline.....Montgomery Co., Ark.	
Pharmacosiderite.....	$3 \ddot{\text{Fe}} \ddot{\text{As}} + \ddot{\text{Fe}} \ddot{\text{H}}_2 + 12 \text{H}$	crystalline.....Cornwall, England.	

Torbernite.....	$\ddot{\text{V}}, \ddot{\text{P}} + \ddot{\text{Cu}} \ddot{\text{H}} + 7 \ddot{\text{H}}$	crystals.....	Cornwall, England.
Autunite.....	$\ddot{\text{U}}, \ddot{\text{P}} + \ddot{\text{Ca}} \ddot{\text{H}} + 7 \ddot{\text{H}}$	crystals.....	Autun, France.
Ulexite.....	$\ddot{\text{Si}}, \ddot{\text{B}}, \ddot{\text{Ca}}, \ddot{\text{Na}}, \ddot{\text{K}}, \ddot{\text{H}}$	nodular fibrous.....	Nevada.
Cryptomorphite.....	$\ddot{\text{B}}, \ddot{\text{Ca}}, \ddot{\text{Na}}, \ddot{\text{H}}$	chalky.....	Oregon.
Wolframite.....	$(\ddot{\text{Fe}} \ddot{\text{Mn}}) \ddot{\text{W}}$	massive.....	Zinnwald, Bohemia.
Hübnerite.....	$\ddot{\text{Mn}} \ddot{\text{W}}$	massive.....	Nye Co., Nev.
Scheelite.....	$\ddot{\text{Ca}} \ddot{\text{W}}$	crystals.....	Zinnwald, Bohemia.
Wulfenite.....	$\ddot{\text{Pb}} \ddot{\text{Mo}}$	crystals.....	Mies, Carinthia.
Barite.....	$\ddot{\text{Ba}} \ddot{\text{S}}$	massive...	Pillar Point, N. Y.
Celestite.....	$\ddot{\text{Sr}} \ddot{\text{S}}$	crystals.....	Stroutian Is., L. Erie.
Anhydrite.....	$\ddot{\text{Ca}} \ddot{\text{S}}$	crystals..	Durkheimberg.
Crocoite.....	$\ddot{\text{Pb}} \ddot{\text{Cr}}$	crystalline....	Hungary.
Brochantite.....	$\ddot{\text{Cu}} \ddot{\text{S}} + 2\ddot{\text{J}} \ddot{\text{Cu}} \ddot{\text{H}}$	crystalline....	Chili.
Mercury.....	$\ddot{\text{Hg}}$	liquid.....	-----
Arsenic.....	As_4	massive.....	Germany.
Graphite.....	C	foliated.....	Ticonderoga, N. Y.
Aragonite.....	$\ddot{\text{Ca}} \ddot{\text{C}}$	crystalline.....	N. Y.

One hundred and six species.

28. The minerals of the foregoing list were submitted to the action of the following reagents successively : (1) A solution of citric acid saturated at the temperature of the laboratory, say 65° to 70° Fahrenheit ; this we call simply "citric acid." (2) The same solution to which solid sodium (or potassium) nitrate is added, which for convenience we shall call the "nitro-citric mixture" (3) The same solution to which solid potassium iodide is added at the time of testing, and which for simplicity we shall designate as the "iodo-citric mixture."

The action of these reagents was studied in the simple manner detailed in our first paper. The mineral to be examined was carefully freed from its associated gangue and finely pulverized in an agate mortar ; a portion was placed in a test-tube, the solution of the acid was added, and the resulting phenomena, in the cold, and on boiling, carefully noted. In many instances the partial decomposition of the mineral was ascertained by filtering from the residue, and testing the solution with an appropriate reagent ; or by examining the disengaged gas with a suitable test-paper.

SULPHIDES, ARSENIDES, ETC.

29. Minerals of this group treated with citric acid alone, yielded results as follows :

- (a) Clausthalite and leucopyrite dissolve in the cold without liberation of gas.
- (b) Alabandite is very strongly attacked in the cold, with evolution of sulphuretted hydrogen. On applying heat it is wholly soluble. In this respect alabandite appears to be the most easily decomposed of all the sulphides yet examined, 37 in number.
- (c) Boulangerite, jamesonite, and kermesite are more or less attacked by boiling citric acid, yielding sulphuretted hydrogen. The remaining minerals of this group resist the action of cold or hot citric acid. Sulphur is absolutely unattacked even when the citric acid solution is heated to the melting point of the element.

The powerful solvent action of a mixture of citric acid and sodium nitrate was discussed in our first paper (19), here we

need only add that the intensity of action claimed for it is fully maintained by later researches.

- (d) All the minerals of the first group, 25 in number, with three exceptions, dissolve in the nitro-citric mixture rapidly and completely, several of them yielding solutions of characteristic color. Even sulphur itself is decidedly attacked, with formation of sulphuric acid. The exceptions are realgar, orpiment, and proustite.
- (e) Two of these, realgar and orpiment, are partially decomposed by boiling with the iodo-citric mixture. Proustite and sulphur resist even on prolonged heating. All the remaining minerals of this group are quite readily dissolved, the decomposition of the sulphides being accompanied by liberation of sulphuretted hydrogen.

The differentiating power of these solvents is again exhibited by these reactions. In our first paper we showed, that while bornite and pyrrhotite are decomposed by citric acid, their kindred compounds, chalcopyrite and pyrite, are not (13). We now find that proustite resists completely the decomposing solutions named, while pyrargyrite is decidedly attacked by the nitro-citric mixture as well as by the iodo-citric mixture, even in the cold.

This difference in behavior of the two closely allied minerals was established by numerous determinations.

OXIDES.

30. The oxides examined include such stable minerals as corundum, spinel, chrysoberyl, cassiterite, rutile, hyalite, and quartz, which naturally resist these methods of attack.

Gummite is attacked by cold citric acid, and melaconite and goethite are soluble to a certain extent on heating. Menaccanite and washingtonite are feebly attacked by the nitro-citric mixture and strongly by the iodo-citric solution. This latter also strongly attacks braunite and goethite.

SILICATES.

31. Silicates are very unequally attacked by citric acid as well as by mineral acids.

- (a) Nephelite, lapis lazuli, laumontite, herschelite, thomsonite, mesolite, and prochlorite, are decomposed by citric acid in the cold, a portion of them with formation of a jelly.

Tephroite, ilvaite, giesckite, jefferisite, henlandite, and genthite, are strongly attacked on boiling with the citric acid alone. Pargasite, pyrope, almandite, colophonite, phlogopite, bastite, masonite, and allanite (?), are feebly attacked. Some doubt obtains, however, as to the last named, because the specimens examined were partially decomposed on the surface.

- (b) The addition of sodium nitrate to the solution of citric acid does not notably increase its solvent power as respects silicates, but the addition of potassium iodide aids decidedly in effecting their decomposition. The iodo-citric mixture strongly attacks the garnets named, as well as enstatite, hypersthene, pargasite, epidote, and those named in paragraph 32.

The feldspars resist these reagents, yet orthoclase and labradorite give up iron to them. Petalite, actinolite, asbestos, beryl, zircon, vesuvianite, zoisite, iolite, lepidolite, leucite, andalusite, fibrolite, topaz, titanite, stanrolite, and kaolin, either wholly resist or give to the attacking solution only a trace of iron.

The variety of serpentine known as bowenite resists citric acid, while serpentine itself, of a normal character, is decomposed.

On the whole, citric acid attacks the silicates with a power nearly approaching that of hydrochloric acid.

REVISION OF THE SILICATES.

32. While carrying on these researches we were continually compelled to combat the firmly grounded impression that the organic acids are weak as respects mineral species. In conse-

quence of this pre-conceived notion, we overlooked in our first paper the fact, that the decomposition of many silicates takes place at ordinary temperatures, having in fact applied heat at once when conducting the examination.

A closer investigation, however, shows that a saturated solution of citric acid is able to decompose many silicates in the cold, even to the formation of gelatinous silica. This necessitated a revision of the silicates named in our first paper (16), with the following results :—

- (a) Willemite, pectolite, calamine, natrolite, wollastonite, chrysolite, chondrodite, chrysocolla, apophyllite, rhodonite, analcite, chabazite, stilbite, and deweyite, are more or less strongly attacked by cold citric acid,—the first four yielding a jelly.

Datolite, prehnite, serpentine, chrysotile, and retinalite, are attacked on boiling the solution.

- (b) The use of the iodo-citric solution as a solvent having been discovered subsequent to the examination of the silicates named in our first paper, a further revision of this group became necessary. The results are briefly as follows :—

Olivine, angite, almandite, and epidote, heated with the iodo-citric mixture, are strongly attacked. Orthoclase, labradorite, hornblende, and spodumene, are very feebly attacked, or yield only iron to the solution.

Wernerite, albite, diopside, kyanite, talc, muscovite, biotite, ripidolite, and tourmaline, are not attacked.

These changes do not invalidate the accuracy of our published results, and are introduced simply to explain the change in position of these minerals in the Tables at the close of this paper.

SUNDRY MINERALS.

33. Under this head are grouped phosphates, arseniates, tungstates, sulphates, etc., as stated in the list given in (27).

A large number, chiefly phosphates, dissolve easily in a cold solution of citric acid : these embrace the following :—

Mimetite, triphylite, triplite, libethenite, olivenite, ataca-

mite, pseudomalachite, wavellite, pharmacosiderite, torbernite, antunite, nlexite, cryptomorphite, and brochantite. Wulfenite and crocoite are strongly attacked on boiling, the latter yielding a green solution, owing to the reducing action of the organic acid on the chromic acid.

Columbite and wolframite are attacked by the iodo-citric mixture, at least so far as partially to dissolve the iron which forms one of their constituents.

Hübnerite is attacked by the nitro-citric mixture; while scheelite, barite, celestite, anhydrite, and graphite, resist completely these methods of attack.

Native Elements.—In our first paper we called attention to the solvent power of the nitro-citric mixture, as shown by the fact that it dissolves metallic copper, silver, lead, tin, bismuth, and antimony, besides iron, zinc, and magnesium, (20); to this list we now add arsenic and mercury.

TABULATION OF RESULTS.

34. In paragraph (22) we gave a table showing the behavior of ninety minerals with citric acid and other reagents, arranged under eleven heads, viz. :—

- A. Minerals which dissolve in cold citric acid without evolution of gas.
- B. Minerals which dissolve in cold citric acid with liberation of carbonic anhydride.
- C. Minerals which are decomposed by cold citric acid with evolution of sulphuretted hydrogen.
- D. Minerals which dissolve in hot citric acid without evolution of gas.
- E. Minerals which dissolve in hot citric acid with liberation of carbonic anhydride.
- F. Minerals which are decomposed by hot citric acid with evolution of sulphuretted hydrogen.
- G. Minerals which are decomposed by hot citric acid with formation of gelatinous silica.
- H. Minerals which are decomposed by hot citric acid with separation of slimy silica.

- I. Minerals decomposed by boiling with citric acid and sodium nitrate.
- K. Minerals decomposed by heating with citric acid and ammonium fluoride.
- L. Minerals which are not attacked by any of these methods.

To this we added, in a subsequent paper, a twelfth group, viz. :—

- M. Minerals decomposed by heating with citric acid and potassium iodide.

In the Tables accompanying this paper we have combined, on a similar plan, the results obtained in the present and previous communications, thus giving a comprehensive view of the behavior of two hundred minerals with citric acid. The arrangement differs somewhat from the foregoing ; we have re-adjusted the silicates to accord with facts stated in (32), and we have omitted the reaction with ammonium fluoride as of no importance in determining species.

To ascertain the exact position for each mineral has been no trivial task ; and should errors be discovered, we crave indulgence, and beg our friends to remember the French saying :—*“ Ceux qui ne se trompent jamais sont ceux qui ne font rien.”*

SUMMARY.

35. The number of minerals examined, though considerable, if we regard the labor involved, is but small compared with those which remain to be treated by these methods, and any attempt at generalization must be correspondingly weak.

It may, however, be admissible to study the Tables with a view to determining whether there is any relation, peculiar to the organic acid, between its solvent power and the chemical constitution of the minerals. This question may be considered from two standpoints, corresponding to two methods of classifying minerals, viz., with reference to their acidic and to their basic constituents.

(a.) The first method of grouping the minerals is the same as that of the list given (27) ; the question applied to them may be answered thus :—

All carbonates and phosphates are decomposed by citric acid.

The sulphides are very unequally attacked ;—two resist the solvents, three yield only to the iodo-citric mixture, twenty-two only to the nitro-citric mixture, and ten are attacked by the acid alone. The oxides and anhydrous silicates are very unequally attacked.

The hydrous silicates are (with one or two exceptions) decomposed by citric acid alone.

(b.) An examination of the influence of the basic constituents on the solubility discloses the following points.

All the copper minerals are soluble in one or more of the solvents.

All the manganese minerals are decomposed,—the sulphide and the silicates with great facility.

All the lead minerals are decomposed by citric acid alone.

In some cases the presence of lead would seem to render a mineral easily broken up ; this is marked in the case of the sulphides, which, as we have seen, are very unequally attacked ;—thus selenide of lead is attacked and selenide of mercury is not ; sulphide of lead is attacked, while sulphide of silver is not. The minerals jamesonite, bournonite, and boulangerite (containing lead) are attacked, while the closely allied species stephanite, tennantite, polybasite, proustite, berthierite, etc. (devoid of lead) are not decomposed.

These facts may possibly point to a connection between chemical constitution and solubility, peculiar to the reagent employed ; but we offer the suggestion with diffidence, owing to the limited number of facts on which to base generalizations. Moreover we find that the results obtained by the *prolonged* action of citric acid on minerals (10 to 30 days), differ greatly from those here recorded. To this we shall return at a subsequent period.

In conclusion, we beg leave to remind our readers that the immediate object in view, as was stated at length in our first paper, is the practical application of these methods to the examination of minerals in the field.

Trinity College, Hartford, Conn.

Tables showing the Behavior of certain Minerals with Citric Acid, alone and with Reagents.

I.

DECOMPOSED (IN FINE POWDER) BY A SATURATED SOLUTION OF CITRIC ACID.

I.—IN THE COLD.

A.	B.	C.	D.
<i>Without evolution of Gas.</i>	<i>With liberation of CO₂.</i>	<i>With liberation of H₂S.</i>	<i>With separation of SiO₂.</i>
Clausenthalite, Leucopyrite, Atacamite, Brucite, Gummite, Pyromorphite,* Mimeticite, Triphylite, Triplite, Vivianite,! Libethenite,! Olivenite,! Pseudomalachite, Wavellite, Pharmacosiderite! Torbernite, Autunite, Ulexite,! Cryptomorphite,! Anglesite, Brochantite.!	Calcite,! Dolomite,* Gurhofite,! Ankerite,* Rhodochrosite,* Smithsonite,* Aragonite,! Witherite,! Strontianite,! Barytocalcite,! Cerussite,! Malachite,! Azurite.*	Stibnite, Galenite, Alabandite, Sphalerite, Pyrrhotite.	Wollastonite, Rhodonite,! Chrysolite, Willemite,!‡ Nephelite, Chondrodite, Lapis lazuli, Pectolite,!‡ Laumontite,!‡ Chrysocolla,! Calamine,!‡ Apophyllite, Thomsonite,! Natrolite,!‡ Mesolite,! Analcite, Chabazite, Herschelite,!‡ Stilbite, Deweylite, Prochlorite.

2.—ON BOILING.

E.	F.	G.	H.
<i>Without evolution of Gas.</i>	<i>With liberation of CO₂.</i>	<i>With liberation of H₂S.</i>	<i>With separation of SiO₂.</i>
Cuprite, ! Zincite, Melanconite, Goethite, * Limonite, * Allanite, (?) Apatite, * Wolframite, * Wulfenite, Crocoite, Gypsum.	Hausmannite, † Pyrolusite, † Manganite, † Psilomelane, † Wad, † Magnesite, ! Siderite, !	Bornite, Jamesonite, * Bonnonite, Boulangerite, Kerнесite.	Tephroite, ‡ Hvite, Phlogopite, * Dtalolite, † Prelmite, * Heulandite, Serpentine, Chrysotile, Retinalite, Bastite, Genthite, Giesseckite, * Jefferisite, Masonite, *
<i>and those in A.</i>	<i>and those in B.</i>	<i>and those in C.</i>	<i>and those in D.</i>

II.

DECOMPOSED BY A BOILING SOLUTION OF CITRIC ACID, MIXED

I.—WITH SODIUM NITRATE.

Silver, Mercury, Copper, Arsenic, Antimony, Bismuth, Sulphur, * Bismuthinite, Domeykite, ! Argentite, Hessite, Chalcocite, ! Tiemannite, ! Millerite, ! Nicolite, ! Pyrite, ! Chalcopyrite, ! Limonite, Smaltite, !	Cobaltite, ! Ullmannite, ! Marcasite, ! Arsenopyrite, ! Nagyagite, Covellite, ! Berthierite, ! Pyrrargyrite, Tetrahedrite, ! Tennantite, ! Stephanite, Polybasite, ! Enargite, ! Uraninite, ! Hübnerite, <i>and those in C and G.</i>
---	--

K.—WITH POTASSIUM IODIDE.

Realgar, * Orpiment, * Cinnabar, ! Hematite, * Menaccanite, * Washingtonite, * Magnetite, * Franklinite, Braunite, Enstatite, Hypersthene, Augite, Spodumene, * Hornblende, * Actinolite, * Pargasite, * Olivine, <i>and most of those in A, B, C, D, E, F, G, H, and I.</i>	Almandite, Pyrope, Colophonite, Epidote,
---	---

III.

MINERALS NOT DECOMPOSED BY THE ABOVE REAGENTS.

Graphite,	Iolite,	Talc,	Labradorite,
Molybdenite,	Biotite,	Kaolin,	Oligoclase,
Proustite,	Muscovite,	Rapidolite,	Albite,
Fluorite,	Lepidolite,	Columbite,	Orthoclase,
Cryolite,	Wernerite,	Samarskite,	Tourmaline,
Corundum,	Leucite,	Spinel,	Scheelite,
Diopside,	Andalusite,	Chromite,	Barite,
Petalite,	Fibrolite,	Chrysoberyl,	Celestite,
Asbestos,	Kyanite,	Cassiterite,	Anhydrite.
Beryl,	Topaz,	Rutile,	(Two hundred
Zircon,	Titanite,	Quartz,	species.)
Vesuvianite,	Staurolite,	Hyalite,	
Zoisite,	Bowenite,	Anorthite,	

N. B.—The gases evolved are examined with acetate of lead test-paper the solutions with appropriate reagents.

The kind and degree of action are indicated in the above Tables by the following signs :—

! Completely decomposed or dissolved.

* Feebly attacked.

† The CO_2 evolved is derived from the Citric Acid.

‡ Gelatinizes.



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APPLICATION
OF
ORGANIC ACIDS
TO THE
EXAMINATION OF MINERALS.
THIRD PAPER.

By H. CARRINGTON BOLTON, Ph. D.
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From the PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT
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APPLICATION OF ORGANIC ACIDS TO THE EXAMINATION OF MINERALS. *Third Paper.* By H. CARRINGTON BOLTON, of Hartford, Conn.

37. In the two papers previously published under the same title¹ we have shown that citric acid has a power of decomposing minerals little less than that possessed by hydrochloric acid, and that the organic acid can be advantageously employed in field-work for assistance in determining species. In the second of these papers we stated that the results obtained by the *prolonged* action of citric acid on minerals differed greatly from those recorded in the accompanying tables, and gave notice of our intention to return to the subject at a subsequent period. We have continued our researches and gained a few additional facts which we deem of sufficient interest to warrant a third or supplementary paper on the subject.

The results given in the tables (here reproduced for convenience) were obtained by acting on the minerals in fine powder: first, in the cold for a few hours, and secondly, at a boiling heat for a few minutes. We find, however, that many species which resist the brief action of a boiling concentrated solution of citric acid are more or less completely decomposed by prolonged contact with the same solution at the ordinary temperature of the work-room, say 60° to 70° Fahr. But a small number of the two hundred minerals embraced in the tables were submitted to the prolonged action of the acid solution, and those tested were selected as representative of groups, sulphides, oxides, silicates, etc. The progress of decomposition was noted at various periods from a few days to more than two years. A solution of citric acid concentrated in the cold was used in all the experiments.

38. *Sulphides.* Chalcocite showed signs of decomposition at the end of ten days, and at the expiration of several months yielded a partial solution of a pure green color.

Ullmannite showed signs of decomposing in two days, and afforded in a month a very dark colored solution.

Arsenopyrite was attacked in a few days. Pyrite showed decided evidence of decomposition in eight days; one month later the solution acquired a reddish yellow color and reacted for iron and sulphuric acid.

¹ Annals N. Y. Acad. Sciences. Vol. I, p. 1, 1877, and Vol. II, p. 1, 1880.

Chalcopyrite acts similarly, the solution being of a greenish yellow hue and reacting for copper and sulphuric acid. One gramme of the mineral lost about eleven per cent of its weight after fourteen months' contact with the acid solution. In general quantitative experiments were not conducted, for it soon became clear that the amount of decomposition was proportionate to the time and would require more attention than the results to be gained warranted.

Smaltite was decidedly attacked after eight days — the presence of sulphuric acid in the colored solution was noted. Tetrahedrite was strongly attacked in about four months. Cinnabar, orpiment, argentite and pyrargyrite resisted the acid solution altogether.

39. *Oxides.* The experiments recorded in this brief supplement were made with only those minerals which resisted the acid solution on boiling, and since it was obviously useless to test such bodies as quartz, corundum, rutile, etc., only the three oxides of iron remained of this class for examination.

Magnetite and limonite were strongly attacked in eight days; hematite yielded much more slowly, showing decided decomposition after several months.

Exposure to sunlight, as might be expected, diminished the intensity of the colored iron solutions.

40. *Silicates.* Of the silicates examined datolite is by far the most quickly decomposed by the acid solution; after twenty-four hours it yields gelatinous silica. Datolite should probably be transferred from column H of the tables to column D.

Hornblende, pyroxene, almandite, epidote, vesuvianite and serpentine were decidedly decomposed in eight days; after one month hornblende, almandite and epidote yielded colored solutions and slimy silica, and serpentine gave gelatinous silica. After fourteen months contact with the acid solution (occasionally agitated) the hornblende and pyroxene were very completely decomposed, the solutions having a dark brown color and full of floating silica. Actinolite seems to be less easily decomposed than common black hornblende. The serpentine after fourteen months yielded a dry gelatinous mass.

The feldspars are very unequally attacked under similar conditions. Labradorite yields the easiest, decomposition being noticed after eight days and slimy silica forming in the course of some months. Orthoclase and oligoclase showed marked signs of decomposition after eight months, but albite is doubtful. Tourmaline

and staurolite yielded to the acid after four or five months, the latter forming a solution colored by iron and slimy silica. Talc and kyanite appear to resist the action of citric acid.

Muscovite and biotite yield very slowly, the latter showing signs of decomposition the sooner. After two years' subjection to the acid solution very minute scales of mica separate, and some slimy silica appears in the slightly colored liquid.

41. We have detailed these simple observations somewhat minutely because we believe they have an important bearing on geological disintegration and erosion. At the Saratoga meeting of the A. A. A. S., my friend Dr. Alexis A. Julien presented an exhaustive summary and analysis of all known observations, concerning the geological action of the humus acids²; in this paper he notes the negative character of the results I had obtained with a number of minerals, *e. g.*, pyrite, augite, hornblende, the feldspars, micas, etc., and says: "but the nature and strength of the solvent employed, and the brief duration of each trial seem at present insufficient to justify generalizations, notwithstanding the suggestiveness of certain results." My subsequent observations have confirmed his views. Generalization is still of doubtful value, yet we are tempted to make the venture. In the following table we have arranged the chief rock-forming minerals, with a

T A B L E
SHOWING APPROXIMATE RELATIVE DISINTEGRATION OF ROCK-FORMING
(AND ASSOCIATED) MINERALS BY CITRIC ACID IN SOLUTION.

<i>Quickly decomposed.</i>	<i>Slowly decomposed.</i>	<i>Very slowly decomposed.</i>	<i>Not decomposed.</i>
Carbonates, Phosphates, Prochlorite, Chrysolite, Nephelite.	Serpentine, Pyroxene, Hornblende, Labradorite, Garnet, Epidote, Vesuvianite, Pyrite, Limonite, Magnetite, Gypsum (?).	Orthoclase, Oligoclase, Albite (?), Biotite, Muscovite, Tourmaline, Staurolite, Hematite.	Quartz, Corundum, Spinel, Beryl, Fluorite, Barite, Talc (?), Kyanite (?).

few of their associates, under four heads indicating their relative disintegration by citric acid; the position of each mineral is of course only approximate, and it is not intended to indicate that all the species in one column are equal in degree of their decomposition. The application of this table to the consideration of

² Proceedings Am. Assoc. Adv. Sci., Saratoga Meeting, Vol. 23, p. 311, 1879.

geological phenomena is a subject which I do not venture to discuss ; if we have a right to assume that the disintegrating effect of the acids of humus differs from that of the other organic acids in degree rather than in kind, the Table may prove a small contribution to chemical geology.

TABLES

SHOWING THE BEHAVIOR OF CERTAIN MINERALS WITH CITRIC ACID, ALONE AND WITH REAGENTS.

I.			
DECOMPOSED (IN FINE POWDER) BY A SATURATED SOLUTION OF CITRIC ACID.			
1. IN THE COLD.			
A. <i>Without evolution of gas.</i>	B. <i>With liberation of CO₂.</i>	C. <i>With liberation of H₂S.</i>	D. <i>With separation of Si O₂.</i>
Clausthalite, Leucopyrite, Atacamite, Brucite, Gummite, Pyromorphite,* Mimetite, Triphylite, Triphile, Vivianite,† Libethenite,† Olivinite,† Pseudomalachite, Wavellite, Pharmacosiderite,† Torbernite, Autunite, Ulexite,† Cryptomorphite,† Anglesite, Brochantite.†	Calcite,† Dolomite,* Gurhofite,† Ankerite,* Rhodochrosite,* Smithsonite,* Aragonite,† Witherite,† Strontianite,† Barytoalcite,† Cerussite,† Malachite,† Azurite.*	Stibnite, Galenite, Alabandite,† Sphalerite, Pyrrhotite.	Wollastonite, Rhodonite,† Chrysolite, Willemite,†† Nephelite, Lapis lazuli, Chondrodite, Pectolite,†† Laumontite,†† Chrysocolite,† Calamine,†† Apophyllite, Thomsonite,† Natrolite,†† Mesolite,† Analcite, Chabazite, Herschelite,† Stilbite, Deweyite, Prochlorite.
2. ON BOILING.			
E. <i>Without evolution of gas.</i>	F. <i>With liberation of CO₂.</i>	G. <i>With liberation of H₂S.</i>	H. <i>With separation of SiO₂.</i>
Cuprite,† Zincite, Melanconite, Goethite,* Limonite,* Aflanite, (?) Apatite,* Wolframite,* Wulfenite, Crocoite, Gypsum.*	Hausmannite,† Pyrolusite,†† Manganite,† Psilomelane,†† Wad,†† Magnesite,† Siderite.†	Bornite, Jamesonite,* Boursonite,* Boulangerite, Kermesite.	Tephroite,† Ilvaite, Phlogopite,* Datolite,†† Prehnite,* Heulandite, Serpentine, Chrysotile, Retinalite, Bastite,† Genthite, Giesseckite,* Jefersite, Masonite.*
<i>and those in A.</i>	<i>and those in B.</i>	<i>and those in C.</i>	<i>and those in D.</i>

II.

DECOMPOSED BY A BOILING SOLUTION OF CITRIC ACID MIXED

I. WITH SODIUM NITRATE.		K. WITH POTASSIUM IODIDE.	
Silver, Mercury, Copper, Arsenic, Antimony, Bismuth, Sulphur,* Bismuthinite, Domeykite,† Argentite, Hessite, Chalcocite,‡ Tiemannite,‡ Millerite,‡ Nicolite,‡ Pyrite,‡ Chalcopyrite,‡ Linnaeite, Smaltite,‡	Cobaltite,‡ Ullmannite,‡ Marcasite,‡ Arsenopyrite,‡ Nagayzite, Covellite,‡ Berthierite,‡ Pyrrargyrite, Tetrahedrite,‡ Tennantite,‡ Stephanite, Polybasite,‡ Enargite,‡ Uraninite,‡ Hübnerite. <i>and those in C and G.</i>	Realgar,* Orpiment,* Cinnabar,‡ Hematite,* Menaccanite,* Washingtonite,* Magnetite,* Franklinite, Braunite, Enstatite, Hypersthene, Augite, Spodumene,* Hornblende,* Actinolite,* Pargasite,*	Olivine, Almandite, Pyrope, Colophonite, Epidote. <i>and most of those in A, B, C, D, E, F, G, H, and I.</i>

III.

L. MINERALS NOT DECOMPOSED BY THE ABOVE REAGENTS.

Graphite, Molybdenite, Proustite, Fluorite, Cryolite, Corundum, Diopside, Petalite, Asbestos, Beryl, Zircon, Vesuvianite, Zoisite,	Iolite, Biotite, Muscovite, Lepidolite, Wernerite, Leucite, Andalusite, Fibrolite, Kyanite, Topaz, Titanite, Staurolite, Bowenite,	Talc, Kaolin, Ripidolite, Columbite, Samaraskite, Spinel, Chromite, Chrysoberyl, Cassiterite, Rutile, Quartz, Hyalite, Anorthite,	Labradorite, Oligoclase, Albite, Orthoclase, Tourmaline, Scheelite, Barite, Celestite, Anhydrite. (Two hundred species.)
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N. B.—The gases evolved are examined with acetate of lead test paper, the solutions with appropriate reagents.

The kind and degree of action are indicated in the above Tables by the following signs:—

‡ Completely decomposed or dissolved.

* Feebly attacked.

† The CO₂ evolved is derived from the Citric Acid.

‡ Gelatinizes.

Bolton, H. C. 1879



THE
Behavior of Natural Sulphides
WITH
IODINE AND OTHER REAGENTS;

BY
Henry
H. CARRINGTON BOLTON, Ph. D.

Professor of Chemistry in Trinity College, Hartford, Conn.

[From the Annals of the N. Y. Academy of Sciences, Vol. 1 No. 5.]

1879

1879. Oct. 1

copy
The Author,
of Hartford.

XV.—*Behavior of Natural Sulphides with Iodine and
other Reagents.*

BY H. CARRINGTON BOLTON, PH.D.

Read March 18, 1877.

In a paper on the "Application of Organic Acids to the Examination of Minerals," presented to the Academy about a year ago,* we endeavored to show that citric (or tartaric) acid and potassium nitrite can be advantageously added to the usual list of dry reagents employed in the determination of minerals. Owing to the facility with which the latter reagent is decomposed by the former, nitric acid can be carried practically in the solid form; hydro-potassium sulphate, already in use,† furnishes sulphuric acid in a solid state; and it remains therefore to provide for hydrochloric acid, or chlorine. The alkaline chlorides, however, resist the action of organic acids; and a few experiments with easily decomposing sulphides yielded only negative results. Iodine, on the other hand, while less powerful than chlorine, possesses similar properties, and in aqueous solution it attacks many minerals, giving rise to characteristic phenomena.

The employment of bromine in analytical operations‡ has already demonstrated its power in decomposing natural sulphides; and it is precisely with these minerals that the most satisfactory results are obtained by the action of iodine.

The specimens named below are the same as those whose source and condition have been described in the paper referred to. The method of examination is exceedingly simple; the minerals in fine powder are placed in test tubes, a small quantity of pulverized iodine is added, and then water poured on; after standing in the cold for some hours (usually over

* *Annals N. Y. Acad. Sci.*, Vol. I, p. 1.

† *Distinction of Natural Sulphides by Bisulphate of Potassa*; E. Jannettaz (*Trausl. from Comptes Rendus*). *Am. Chem.*, IV, 450.

‡ P. Waage; *Zeitschr. anal. Chem.*, 1871.

night), the results are noted; the contents of each tube are then heated to boiling, and the results again recorded. The solutions were tested by suitable reagents after expelling by heat the excess of iodine.

Stibnite, treated in the manner described, is strongly attacked; and with excess of iodine the solution turns deep brown-red. On boiling the red solution, it loses color as the iodine volatilizes, and after the latter is completely expelled, suitable reagents demonstrate the presence of sulphuric acid and of antimony. The decomposition of this mineral is complete.

Molybdenite is not attacked either in the cold or on boiling.

Argentite is attacked in the cold, yielding a red solution and a yellowish-white precipitate. If an excess of iodine be present, the mineral is completely decomposed in the cold.

Galenite is decomposed in the cold, the liquid being completely decolorized. Lustrous, yellow crystals of plumbic iodide form on the surface of the mineral. On heating, the action is increased; and the solution deposits, on cooling, large and abundant crystals.

Bornite is strongly attacked in the cold, the solution being brown-red and the residue yellowish-white. On heating, the decomposition is hastened, and a heavy precipitate of cuprous iodide forms.

Sphalerite is strongly attacked in the cold, the solution turning dark-red and a crystalline precipitate forming. On heating, the decomposition is complete.

Chalcocite is strongly attacked in the cold, the solution with excess of iodine being brown-red. On the application of heat, the action is increased, but little (if any) cuprous iodide forms.

Cinnabar is strongly attacked in the cold. On heating, it is readily decomposed, with formation of small scarlet crystals of mercuric iodide.

Pyrrhotite is strongly attacked in the cold; the solution is not completely decolorized, and becomes darker on heating.

Pyrite is decidedly attacked in the cold; on boiling, the

action is increased, but the decomposition appears to be incomplete.

Niccolite is strongly attacked in the cold, yielding a green solution, which turns brown on heating with excess of iodine.

Smaltite is strongly attacked in the cold, forming a brown-red solution; heat increases the action.

*Chalcopyrite** yields a deep-red solution in the cold; the action is increased by boiling, but no precipitate forms.

Tetrahedrite, *ullmannite*, and *arsenopyrite* behave like chalcopyrite.

Bournonite yields a deep-red solution in the cold; and on heating, a heavy precipitate falls, which is evidently a mixture of plumbic iodide with yellowish-white cuprous iodide.

From the preceding notes, it appears that molybdenite is the only one of the seventeen sulphides examined which resists the action of an aqueous solution of iodine. The reactions of galenite and cinnabar are characteristic and beautiful; that of bournonite discloses its composition very satisfactorily. The difference of behavior between bornite and chalcocite is marked.

The results obtained with pyrite and pyrrhotite require some explanations. Professor Henry Wurtz,† in 1858, employed iodine-water to separate pyrrhotite from pyrite; he states that pulverized pyrite digested for 48 hours in the dark with a brown solution of iodine (pulverized and washed repeatedly to remove all free acid), "did not remove the brown color of the liquid, and the latter had dissolved but a trace of iron." We repeated this process, observing all the precautions mentioned, and found that pyrites (from Colorado, and from Saxony), was decidedly attacked. Possibly the discrepancy is only one of judgment as to the amount of decomposition which ensues, but under ordinary circumstances

* Menzel has studied the behavior of chalcopyrite with hydriodic acid; Ber. chem. Ges. III, 133; 1870.

† On some Improvements in the Preparation of Hard Minerals for Analysis, read before the A. A. A. S. at the Baltimore meeting. Am. J. Sci., [2] Vol. XXVI. p. 190.

we are confident that iodine (in excess) with water decomposes pyrite.

Besides the natural sulphides, we examined the behavior of a few minerals, belonging to various classes, with an aqueous solution of iodine. Limonite, hematite, magnetite, and the manganese oxides, as well as pyromorphite and calamine, are not attacked even on boiling the solution. Cuprite is completely decomposed in the cold, with formation of a bright green crystalline precipitate (CuIO_2 ?). Brucite, calcite, and natrolite, are decidedly attacked on boiling. Anglesite is feebly attacked in the cold, and strongly on heating; cerussite and vivianite appear to be slightly decomposed under the same circumstances. None of these reactions have special interest, except perhaps that of cuprite, which is quite characteristic.

Having continually in mind the possible application of methods to the examination of minerals in the field, and recognizing the impracticability of carrying iodine save in glass bottles, we were led to make another series of experiments with a view to providing iodine in a portable state. To this end, we took advantage of the ready decomposition of potassium iodide by organic acids. That even the weakest acids are able to set hydriodic acid free, in acting on the iodides of the alkaline metals, has been frequently noticed,* and we add the following observations:

When solid potassium iodide is added to strong acetic acid, in the cold, hydriodic acid is set free; and after standing for some time (24—48 hours), this acid decomposes, and the free iodine communicates to the solution a brownish-red color of varying intensity. With free access of air, the liberation of iodine begins at once, as shown by testing the mixture with carbon disulphide. This action is more marked in strong solutions than in weak.

* Dr. Rudolph Boehm, in his *Handbuch der Spec. Pathologie und Therapie*, vol. XV, p. 21, quotes Struve's discovery that even hydro-sodium carbonate decomposes potassium iodide in dilute aqueous solution. This power of carbonic acid has also been observed by Kammerer (*Virchow's Archiv*, LIX, 1874), and Binz (*ibid.*, LXII).

Tartaric and nitric acids decompose potassium iodide in a similar manner.

A mixture of any of these organic acids with potassium iodide proves to be a powerful solvent of the natural sulphides. An examination of the seventeen sulphides already mentioned gave the following results :

BEHAVIOR WITH POTASSIUM IODIDE AND CITRIC ACID.

Stibnite, *argentite*, *sphalerite*, *chalcocite*, *bornite* and *ullmannite*, are attacked in the cold, with liberation of sulphuretted hydrogen ; heat increases the action,—the gas coming off freely.

Galenite acts in the same manner, with formation of yellow crystalline flakes of plumbic iodide. On applying heat, the mineral is completely decomposed.

Cinnabar is also decomposed in the cold, with liberation of sulphuretted hydrogen. On boiling, the decomposition is complete, and crystals of mercuric iodide deposit on cooling,—provided no great excess of potassium iodide is present.

Arsenopyrite is decomposed in the cold, but no sulphuretted hydrogen appears to be set free. On boiling, the decomposition proceeds rapidly.

Pyrrhotite, *chalcopyrite*, and *bourbonite* yield no sulphuretted hydrogen in the cold, but freely on heating. The latter is but feebly attacked.

Pyrite, *niccolite*, and *smaltite*, give no sulphuretted hydrogen, either cold or hot, though they are strongly attacked on boiling the liquid.

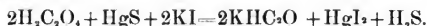
Tetrahedrite is attacked feebly in the cold ; on heating, the action is increased.

Molybdenite resists the action of this mixture of reagents.

Similar results were observed with tartaric and oxalic acids, their decomposing power varying. *Cinnabar*, treated with a mixture of potassium iodide and oxalic acid, is decomposed with remarkable facility ; the reaction sets in immediately and in the cold ; on boiling, the decomposition continues with

violence; and on cooling, the solution deposits white crystals of hydro-potassium oxalate, mixed with scarlet crystals of mercuric iodide.

The probable nature of this reaction is shown in the following equation:



We examined the behavior of a few additional minerals with a mixture of potassium iodide and citric acid, with the results recorded below; but no special interest seems to be attached to this method of attack.

Magnetite is decidedly, and *franklinite* feebly, attacked in the cold, and strongly on heating. *Hematite* is feebly attacked, and *chromite* not at all.

Hausmannite, *pyrolusite*, and the other oxides of manganese, being attacked by citric acid alone, yield, as may be anticipated, deep brown red solutions colored by the iodine.

Anglesite and *pyromorphite* are completely decomposed in the cold, with formation of a yellow precipitate of plumbic iodide.

Cuprite is also completely decomposed in the cold, with formation of a yellowish-white precipitate of cuprous iodide, and a colorless solution. If, however, heat be applied at the outset, the same precipitate forms, while the solution is of a blue color.

We also examined the behavior of natural sulphides with a mixture of citric acid and potassium bromide. The latter does not, however, appear to be so easily decomposed as the iodide, and no characteristic phenomena were observed; nearly all the metallic bromides being soluble in water, no precipitates were obtained. In order to avoid repetition, we may briefly summarize the results by stating that, in general, the action of the bromide is less energetic than that of the iodide. Those minerals which yielded only with difficulty to the latter reagent, resist the former even on heating. Cinnabar, whose behavior with the iodide is so remarkable, is but feebly

attacked by the bromide. Argentite, galenite, sphalerite, chalcocite, pyrrhotite, pyrite, and chalcopyrite, are attacked in the cold, with or without liberation of sulphuretted hydrogen. Molybdenite resists this mixture of reagents, as well as the others previously mentioned.

In studying the behavior of minerals with organic acids, we obtained results which were embodied in a Table* exhibiting the eleven groups into which minerals are divided by the action of citric acid alone and with reagents. We are now able to add a twelfth group, viz: "minerals decomposed by heating with citric acid and potassium iodide," and to transfer thereto, from the list of "minerals not decomposed by the above reagents," four species—cinnabar, magnetite, hematite, franklinite.

Thus of the ninety minerals whose behavior with organic acids and reagents has been examined, only nine resist these methods of attack.

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* Ann. N. Y. Acad. Sci., Vol. I, p. 30.

LEGENDS OF

SEPULCHRAL AND PERPETUAL LAMPS.

BY

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LEGENDS OF SEPULCHRAL AND PERPETUAL LAMPS.

EVERY science and every art appears to have had, at some period in its history, aims and aspirations of an unphilosophical and superstitious character; every branch of learning has had its infatuated enthusiasts working at unachievable projects and striving to reach unattainable goals. In astronomy, clever and learned men endeavoured to foretell the fate of mankind by a study of the stars; in mechanics they sought for perpetual motion: in mathematics, for the quadrature of the circle; in medical art for a universal panacea and an elixir of life; and chemical science was for many centuries a fertile field for speculations no less chimerical and unsubstantial.

The extraordinary delusions of the alchemists have been summarised by Wiegleb, a German chemist of the last century, in the following words:—"At one time they turned their attention to the production of pearls and precious stones; at another to the fixation of ordinary mercury, and hence to its extraction from natural metals; some sought to transform water into vinegar, others endeavoured to make glass flexible and malleable. They sought also to prepare for the physician the much-needed elixir of life, to transform common salt into saltpetre, to prepare a universal solvent, *to discover the means of causing lamps to burn perpetually*, to reproduce plants and animals from their ashes, and even to effect the resurrection of the dead! Besides these chimerical pursuits, the favourite and most enticing of all was the transmutation of the common or base metals into silver and gold."*

* WIEGLEB, Hist. Krit. Untersuch. d. Alchemie. Weimar, 1777. 12mo.

The belief in ever-burning lamps mentioned by Wiegleb is not unfrequently alluded to in prose and poetry, yet detailed and exact information on this point is to be had only by patient research. Many volumes have been written on the history of chemistry, and on alchemy, narrating the fanciful views and arduous labours of the would-be transmuters of the base metals, but they seldom make reference to the sepulchral and perpetual lamps.

During the sixteenth and seventeenth centuries a belief in the actual existence of ever-burning lamps seems to have been very real and widely prevailing. Many learned writers maintained that the ancients were acquainted with the preparation of a combustible fluid, which, while burning and giving out light, diminished not in quantity and potency. Lamps supplied with this marvellous liquid were placed in tombs by the ancient Romans, and continued burning until some ruthless explorer desecrated the subterranean places of burial and allowed air to enter, whereupon the flame flickered and shortly expired. These astonishing lamps "burned the most brightly where there was most want of air, and were always extinguished by the immission of external air."—(Dr. Plot.)

To discover the secret of preparing this combustible yet inconsumable liquid was one of the alchemist's dreams; in their figurative language they endeavoured to "concentrate the four elements, and to make therefrom a wonder-working essence."—(Kriegsmann.) The material upon which their operations were conducted, and in which they placed great reliance, was fine gold; this, they said, resolved by hermetic methods into a "clear liquid," supplied, by its "incombustible oiliness," the perpetual light. Some authors describe the liquid in question as an "extract of the elements prepared with great labour, and possessing the property, when provided with a suitable ferment of silver or gold, of forming the white or red tincture capable of transmuting the base metals." But without the ferment it nourished the ever-burning lamps, and on account of its exceeding costliness was consecrated to the mythological divinity Pluto." Such is the description of this liquid contained in a rare and quaint little 16mo., entitled "Taaut," written by one Wilhelm Christoph Kriegsmann, and published at Frankfurt in 1665 (page 65 of Notes).

The alchemists did not, however, always employ such enigmatical and obscure language when writing of this mysterious liquid. Trithemius—a learned abbot of the fifteenth century, who found leisure amid his Benedictine duties to

write works on theology, history, philosophy, and alchemy—gives two receipts for making the inexhaustible oil: one of these reads as follows:—

“Mix four ounces of sulphur and four ounces of alum, sublime them, and convert them into flowers. Take two and one-half ounces of these flowers, with half an ounce of borax and Venetian crystal, and pulverise the whole in a glass mortar. Put the powder into a phial, and, having poured into it spirit of wine four times rectified, cause it to digest. Pour off the spirit of wine, and, having added some new, repeat the operation three or four times, until the sulphur runs on hot plates of brass without smoke, like wax. You must then prepare a proper wick, which may be done in the following manner: take filaments of mineral flax of the length of the finger, form them into a packet half as thick as the finger, and tie them with a white silk thread. The wick being thus arranged, cover it with the sulphur prepared as before described, and immerse it in the sulphur in a vessel of Venetian glass. Place the whole upon a sand-bath for twenty-four hours, so that you may always see the sulphur boil, and the wick being by these means well penetrated and impregnated with that aliment, put it into a small glass with a wide mouth. Then fill this vessel with the prepared sulphur and place it in warm sand, that the sulphur may melt and surround the wick. If it be then kindled it will burn with a perpetual flame.”*

It is hardly necessary to add that the process, described with so much care, would prove very unsatisfactory to any curious investigator.

The alchemists also claimed that an inconsumable oil could be obtained by treating gold with oil of vitriol, and they called the product *oleum vitrioli aurificatum*. Other receipts are given by the Jesuit Athanasius Kircher, and will be found by the curious in his “*Mundus Subterraneus*.”†

The belief in perpetual lamps was sustained and diffused by the publication of many legends, which appear to have been freely accepted by a credulous people, notwithstanding their highly improbable character and the slender basis of truth on which they were founded. One of the most famous and oft-quoted legends establishing this superstitious belief was that of the tomb of Tulliola. In the pontificate of Paul III. (1534—1549), the same who convoked the Council of Trent, a tomb was opened, at Rome, which contained the

* TRITHEMIUS, *Tractatus de Lapide Philosophorum*. 1611, 8vo.

† Vol. ii., Lib. 8, Sect. 3, De Asbesto, &c.

body of a young woman in a remarkable state of preservation. Her flesh was uncorrupted,* and her tresses were still bound with a small plate of gold curiously chased and enamelled. A burning lamp hanging in the vault was extinguished as soon as the air entered. On the walls was carved the inscription "*Tulliola filia mea*," which was thought to refer to Tulliola, the daughter of Cicero, whose death he laments in his letters to Servius Sulpicius.† One authority states that the lamp burned several hours after opening the tomb, though it must have been closed more than fifteen hundred years. This legend was the subject of much comment. Montfaucon,‡ the eminent French antiquary and philologist, repudiates the story, and maintains that it is merely the revival of an older tale concerning the discovery of an uncorrupted body, in March, 1485, related by Etienne de Infestura and Alexander ab Alexandro. The latter describes the marvellously perfect preservation of the remains, and adds—"To see the body one would have thought it interred but a short time; there was no inscription, though Pomponius thought it to be the body of Tulliola, daughter of Cicero, or that of Priscilla, wife of Abascantius."

Another legend, which supplied partisans with one of their strongest arguments, was that of the Lamp of Olybius. In the year 1500 some peasants, digging the earth to a considerable depth, near Padua, discovered a tomb containing lighted lamps, one of silver and the other of gold; or, according to another authority, there was but one lamp, placed in an urn between two phials, one filled with liquid gold and the other with liquid silver, by virtue of which the light had been maintained since the days of the Romans. According to inscriptions§ on the urns the lamp had been prepared with great labour by Maximus Olybius. Representations of the two vases, with their inscriptions, are given in Kriegsmann's "*Taaut*," and in several less rare works.|| Licetus,

* Perhaps converted into adipocere (?).

† *Ad Familiares*, iv., 6.

‡ *L'Antiquité Expliquée*. Paris, 1719.

§ *On the smaller urn*:—*Abite hinc pessimi fures! Vos quid voltis vestris cum oculis emissitis? Abite hinc vestro cum Mercurio petasato caduceatoque. Maximus maximo donum Plutoni, hoc sacrum facit.*

On the larger urn;—

"Plutoni sacrum munus ne attingite fures!
 Ignotum est vobis hoc quod in urna latet;
 Namque elementa gravi clausit digesta labore
 Vase sub hoc Modico Maximus Olybius.
 Adsit fecundo custos sibi copia cornu,
 Ne pretium tanti depereat laticis.

|| See PETRI AFRANI, *Inscriptionibus*, p. 337; also LICETUS, FERRARI, and MONTFAUCON.

of whom more hereafter, gives a letter of Maturantius, who tells his friend Alphenus that "Both the urns and the lamps and the phials have fallen into my hands, and are now in my possession. If you saw them you would be astonished. I would not part with them for one thousand crowns of gold." Two similar sepulchral lamps are to be seen in the Museum of Rarities at Leyden.

Many other equally credible narratives were current in the sixteenth and seventeenth centuries. At the time of the suppression of the monasteries by King Henry VIII. (1537) a tomb was opened containing a lamp which had been burning at least twelve hundred years: the authority of Cassidorus was quoted, who says he himself made perpetual lamps for the use of the monks in his monastery at Viviers (about 500 A.D.). Reference was also made to the lamp of Pallas, son of Evander, whose brave deeds were sung by Virgil: this lamp was found at Rome about 800 A.D., and must have burned nearly 2000 years. Even St. Augustine, the most illustrious and holy Father of the Church, was claimed, by partisans of these traditions, as testifying to their truth. St. Augustine, mentioning the lamp in the Temple of Venus, says it "burned perpetually, and the flame adhered so strongly to the combustible matter that neither wind, rain, nor tempests could extinguish it, though continually exposed to the inclemency of the seasons." St. Augustine attempts to explain the marvel, and conjectures that the incombustible wick was made of asbestos, but that the inexhaustible aliment was the work of demons, who wrought the infernal miracle in order to blind the pagans more completely, and to attach them to the infamous deity worshipped in that temple.

The famous chemist Glauber refers to these miraculous lamps in his brief essay entitled "Book of Fires" (*Libellus Ignium*). He writes of a lamp "which, being closed up in a glass, may be made to burn continually by its own virtue, and give light without any other help." He explains the admitted fact that when the "secret fire" is "touched by the least air it extinguisheth and goeth out," by the suggestion that "the fire is appropriated to the Elemental Air," and hath its "own air in itself." Glauber, who was always ready to turn chemical discoveries to medical purposes, writes of this lamp that it may be "very available to those who, by reason of continual weakness, are forced to lie much upon their beds," and that it may be "kept continually burning in their bed-chamber, not only because of its clear shining light which doth neither smook nor scent, like all

other combustible lights, which scent is very prejudicial to the sick as well as to the healthy."*

Even in the eighteenth century we find anecdotes of these ever-burning lamps, clothed with new adornments and skilfully adapted to the later epoch. One of the most entertaining of these legends is that of Rosencreutz, the founder of the mysterious fraternity known as the Rosicrucians. The narrative runs as follows:—A certain person having occasion to dig somewhat deep in the ground, where the philosopher Rosencreutz lay interred, met with a small door having a wall on each side of it. His curiosity, and the hope of finding some hidden treasure, soon prompted him to force open the door. He was immediately surprised by a sudden blaze of light, and discovered a very fair vault. At the upper end of it was a statue of a man in armour, sitting by a table and leaning on his left arm. He held a truncheon in his right hand, and had a lamp burning before him. The man had no sooner set one foot within the vault than the statue, erecting itself from its leaning posture, stood bolt upright, and, upon the fellow advancing another step, lifted up the truncheon in his right hand. The man still ventured a third step, when the statue with a furious blow broke the lamp into a thousand pieces, and left his guest in sudden darkness. Upon the report of this adventure the country people came with lights to the sepulchre, and discovered that the statue, which was made of brass, was nothing more than a piece of clockwork; that the floor of the vault was all loose and underlaid with several springs, which upon any man's treading naturally produced that which had happened. Rosicrucius, said his disciples, made use of this method to show to the world that he had re-invented the ever-burning lamps of the ancients, though he was resolved no one should reap any advantage from the discovery."†

The Comte de Réxie, in his curious "*Histoire et Traité des Sciences Occultes*,"‡ gives a brief account of the sepulchral lamps, and adds the following narrative:—In the reign of St. Louis (1226—1270) there lived in Paris a certain Rabbi named Jechiel, who was regarded by the Jews as a saint and by Christians as a sorcerer. He possessed a lamp which gave out light equal to daylight in brilliancy, which required no oil, and burned unceasingly. But what is more singular still, when honest tradesmen or people of quality came at night to knock at the door, his lamp shone brightly

* GLAUBER'S Works. London, 1689. Part II., p. 216.

† *Spectator*, No. 379, May 15, 1712, written by EUSTACE BUDGELL.

‡ Vol. ii., p. 67, 1857.

as usual, and the Rabbi gave his friendly guests an entrance ; but whenever impostors or persons of evil intent presented themselves at the door, the lamp grew visibly pale, and the Jew took care to fasten the door against the intruder.

The latter half of the seventeenth century witnessed a considerable controversy on the subject of perpetual lamps. On the affirmative side of the question we find the names of the Abbot Trithemius, already mentioned ; John Baptist Porta, the eminent Italian physicist, the same who invented the camera obscura (" *Magiæ Naturalis*," Libri xx., 1558) ; the celebrated Italian engraver and painter, Pietro Santi Bartoli (" *Le antiche Lucerne, &c.*," Roma, 1691, fol.) ; the German antiquary, Lorenz Beger (" *Lucerne, vet. sep. Berol.*," 1702) ; the learned Jesuit, Martin Antoine Delrio (" *Essay on Magic*," 1599), who attributed the lamps to magic skill ; and Fortunius Licetus, the most credulous and erudite of all. On the negative side of the question are arrayed the names of Vigneul-Marville, a French Carthusian monk (1699) ; the learned Jesuit, Athanasius Kircher, whose "*Mundus Subterraneus*" has been already quoted ; the Italian antiquary and Professor of Philosophy, Ottavio Ferrari (" *Dissertatio de Veterum Lucernis*," Padua, 1684, 4to., in Grævius's "*Thesaurus Antiq. Ital.*"); the Italian ecclesiastic, Paolo Aresi, Bishop of Tortona (" *Sacred Emblems*," 1613) ; the English naturalist and antiquary, Robert Plot (" *Phil. Trans.*," Abr. III., p. 100, 1684) ; the German chemist, Libavius (" *Comment. Alchem.*," Part II., Lib. ii., Cap. x., 1595) ; Buonamici, an Italian *litterateur* ; Fabricius ; Montucla ; and many others.

To detail all the points for and against the existence of perpetual lamps made by these writers does not come within the scope of this essay. One of the most earnest supporters of these fables, Fortunius Licetus, deserves a somewhat lengthier notice.

Fortunius Licetus was born in the State of Genoa, October 3rd, 1577. He was the son of a physician, and, having received a liberal education in medicine and philosophy, became professor of these departments of learning at the University of Padua. After holding these chairs for twenty-five years the rival University of Pisa secured his services by a tempting offer ; but nine years later, a vacancy occurring at Padua, he returned to his former position, and held it until his death in 1657. Licetus was a voluminous author, writing fifty treatises on medical, moral, philosophical, antiquarian, and historical subjects, which were distinguished for their erudition, though he displayed little

acuteness in research or originality of conception. His treatise "*De Monstrorum Causis*" (1668) abounds with instances of his credulity and with the superstitions and fables of his predecessors. Of all his works none is more celebrated than his treatise on the Sepulchral and Perpetual Lamps of the Ancients ("*De Lucernis Antiquorum reconditis*," Venet., 1652). This work, of 640 pages in quarto, is written expressly to prove the truth of the traditions concerning sepulchral lamps. The author accumulates a great number of witnesses, ancient and modern, quoting legends of Merlin, Porta, Scardeonius, and many others. The work is abundantly illustrated with engravings of the perpetual lamps, and forms a notable example of misplaced erudition and credulity. In his first book Licetus mentions thirty instances of perpetual lamps, including those connected with the mysteries of the Delphic Oracle, the ceremonies of Jupiter Ammon, and of the Vestal Virgins. The lamp of Demosthenes, which burned in the Temple of Minerva at Athens, also furnished him with a proof of the possibility of an inextinguishable fire. Licetus also relates the testimony of Jacobonus, author of the "*Book of the House of Cesi*," who mentions several persons who had seen these lamps still burning. He confidently relies on the testimony of such an unreliable author as Pausanias (175 A.D.), who speaks of a golden lamp, in the Temple of Minerva, which, when once filled with oil, burned a whole year without replenishing—a marvel which he attributed to the nature of the wick. Licetus refers to the statement of Plutarch, who relates that Cleombrotus, the Lacedemonian, visited the Temple of Jupiter Ammon, and saw a lamp which the priests said burned continually without oil.

Vigneul-Marville, writing of Licetus's work, very justly remarks that in it "Licetus exhausts all the resources at his command, but after all does not inform us of what we most want to know, viz., the secret of these perpetual lamps.

Many endeavours have been made by modern authors to account for the persistence of this belief by reference to natural causes. Montfaucon remarks no one doubts that burning lamps were placed in tombs by the ancients, and gives the following inscription from a tomb at Salerno:—"Adieu Septima; may the earth lie lightly upon you; may a golden oil cover the ashes of him who placed in this tomb a burning lamp."*

* "Have Septima, sit tibi terra levis quisque huic tumulo posuit ardente lucernam illius cineres aurea terra tegat."

Certain writers suggest that the imperishable wicks may have been made of asbestos, or "salamander's wool" as it was called, but they encounter great difficulty in the matter of the "indestructible aliment." Vigneul-Marville ascribes the flames to the "fat and gross vapours engendered by the corruption of dead bodies and enkindled by the torches used in opening a tomb." Dr. Robert Plot, "Director of Experiments to the Philosophical Society of Oxford," read a paper before the Society, in 1684, in which he narrates experiments made to test the value of asbestos for lamp-wicks. He concludes that this material may have been used in the sepulchral lamps, and to account for the inexhaustible oil discourses on a spring of liquid bitumen, or naphtha, such as occurs in Shropshire: a similar suggestion was made by Athanasius Kircher as early as 1665 ("Mundus Subt.," *loc. cit.*). Other writers conjecture that the lights found in the tombs were of phosphorus—meaning thereby not the modern chemical element of this name, but the so-called "Bologna stone," which shines in the dark. The elder Disraeli briefly notices these remarkable legends in his "Curiosities of Literature," and points out the necessity of the oxygen of the atmosphere to ordinary combustion; he considers this fact in itself a sufficient refutation of these singular traditions.

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THE

EARLY PRACTICE OF MEDICINE

BY

WOMEN.

BY

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THE
EARLY PRACTICE OF MEDICINE BY WOMEN.

IN attempting to sketch the history of the entrance of women into the medical profession we find the earlier periods obscured by a meagreness of material and a lack of sequence which our superficial researches have failed to supplement.

Isolated cases of gifted women attaining notable surgical skill and successfully pursuing the divine art of healing are recorded at various epochs in the history of the intellectual development of woman, but they occur at long intervals of time and in widely scattered chronicles. In the following pages we have not undertaken to present an exhaustive history or catalogue of female practitioners of medicine; we have simply collected a few scattered notices, and moulded them into an outline to be hereafter filled up by a more competent hand.

These notices refer to the earlier history only, and by earlier history we mean the period prior to the establishment of medical schools for women, and to the present movement for their higher education. From the earliest times women have successfully grappled with a most difficult branch of medical science, gynecology, but long-existing and deep-seated prejudices prevented an extension of their practice, and, save in exceptional cases, they were forbidden both the acquirement of accurate and systematic knowledge and the exercise of their chosen vocation. So long as the practice of medicine formed a part of the priestly functions, as in

ancient Egypt, the crafty guardians of superstition sedulously concealed their superior knowledge from an ignorant and credulous people, and especially from women. Yet the story of the birth of Moses shows that female gynecologists were not unknown to the Egyptians.

At a later period the Greeks thought to add dignity to the practice of medicine by forbidding it to slaves and (forsooth!) to women. During the Middle Ages, when every branch of Science was more or less dishonoured by degrading superstitions, we find women, as well as men, yielding to their influence and exercising the double calling of sorceress and healer of the sick; nor has the intelligence of the common people even in the nineteenth century reached such a height as to render the business of medical clairvoyant nugatory and profitless.

The invention of medicine was almost universally attributed by the ancients to the gods, and it is a curious fact that in both Egyptian and Grecian mythology we find female deities occupying important relations to the healing art. To the Egyptian deity Isis, the wife and sister of Osiris, peculiar medical skill was attributed, and a multitude of diseases were regarded as the effects of her anger. According to tradition she had given unequivocal proof of her power by the restoration of her son Orus to life. She was the reputed discoverer also of several remedies, and even as late as Galen the *Materia Medica* contained several compounds which bore her name: thus, in the symbolical language of the Egyptian priestly physicians, the vervain was called the "tears of Isis."

According to the annals of Grecian mythology, Hygeia, daughter of Æsculapius, the god of medicine, was worshipped in the temples of Argos as the goddess of health. In art, Hygeia is represented as a virgin wearing an expression of benevolence and kindness, and holding in one hand a serpent which is feeding from a cup in the other. She was regarded as the goddess both of physical and mental health, thereby personifying the aphorism "*Mens sana in corpore sano.*" The Greeks also ascribed medical power to Juno, who, under the name of Lucina, was held to preside over the birth of children; and to Ocyroe, daughter of the Centaur Cheiron, who was renowned for his skill in surgery and medicine. The sorceresses Medea and Circe were said to make use of herbs in their enchantments and for the purpose of counteracting the effects of poisons. These and similar fables probably preserve in allegoric form facts connected with the practice of medicine by women in the remotest antiquity.

The writings of Homer have been examined to ascertain his testimony, but, with the exception of slight reference to woman's part in nursing wounded warriors, he contributes nothing to the subject under consideration.

The learned among the Celts, the Druids, were at the same time judges, legislators, priests, and physicians. By persuading the people that they maintained intimate relations with the gods, they succeeded in imposing their authority on the ignorant masses. "Their wives, who were called *Alraunes*, exercised the calling of sorceresses, causing considerable evil by their witchcraft, but caring for warriors wounded in battle. They gathered those plants to which they attributed magic virtues, and they unravelled dreams." (Dunglison.)

The first female practitioner who received a medical education appears to be Agnodice, a young Athenian woman who lived about 300 B.C. To satisfy her desire for knowledge she disguised herself in male attire, and, braving the fatal results of detection, dared to attend the schools of medicine forbidden to her sex. Among her instructors was numbered Herophilus, the greatest anatomist of antiquity, and the first who dissected human subjects. After completing her studies, Agnodice preserved her disguise and practised her chosen calling in the Grecian capital with great success, giving particular attention to the diseases of her own sex. The physicians of Athens, becoming jealous of Agnodice's great reputation and lucrative practice, summoned her before the Areopagus, and accused her of abusing her trusts in dealing with female patients. To establish her innocence Agnodice disclosed her sex, and her persecutors then accused her of violating the law prohibiting women and slaves from studying medicine, but the wives of the most influential Athenians arose in her defence, and eventually obtained a revocation of the law.

The laws and customs of the Romans, as well as of the Greeks, were antagonistic to the entrance of women into the medical profession, yet Galen, Pliny, and others have preserved the names of a few distinguished in the art of healing: —Phænarete, the mother of Socrates, Olympia of Thebes, Salpe, Sotira, Elephantis, Favilla, Aspasia, and Cleopatra. Of these, details are generally wanting. Scribonius Largus writes of an "honest matron" who cured several epileptic patients by an absurd remedy, and mentions having purchased of a woman a prescription for the cure of cholera, the composition of which she had learned in Africa. Why Aspasia appears in this connection is not perfectly clear;

the talented wife of Pericles, renowned as "a model of female loveliness," was doubtless too involved in affairs of state to undertake the absorbing cares of the medical profession. Cleopatra, the accomplished and luxurious Queen of Egypt, of whom so many marvels are related, is named among those women possessed of medical skill; she is reported to have compounded cosmetics, and to have written on the art of preserving beauty; but this statement is probably no more worthy of credence than that of the infatuated alchemists of the Middle Ages, who would persuade us that Cleopatra was the fortunate possessor of the philosopher's stone and of the universal solvent. In proof of the former statement they point to her personal attractions, unchanged by increasing years, and to her immense wealth; in proof of the latter they rely with confidence on the well-known fable of the solution of the costly pearl at the extravagant banquet to Marc Antony.

In a Roman lady named Fabiola we find an early predecessor of Florence Nightingale. She was of the illustrious house of Fabius, and was celebrated in the fourth century for piety and charity. She is to be held in grateful remembrance as the founder of hospitals in Italy, and she is said to have personally nursed the sick at Ostia. The establishment of hospitals is commonly credited to the Emperor Julian, 362 A.D., with whom Fabiola was contemporary; perhaps she took an active part in the humane movement, and held a position analogous to that of lady manager in modern times.*

Half a century later lived a woman justly distinguished for combining in one person a high degree of female loveliness, womanly virtue, and intellectual strength: though not occupied with the art of healing, we cannot pass in silence the accomplished Hypatia. Born at Alexandria in the latter part of the fourth century, the daughter of Theon, an eminent mathematician and philosopher, she soon excelled her father in these branches of learning. After profiting by profound studies under celebrated masters at Athens and Alexandria, she publicly taught philosophy at both these centres of culture. Gibbon writes of her—"In the bloom of beauty and in the maturity of wisdom, the modest maid refused her lovers and instructed her disciples." On Hypatia's inhuman murder, at the instigation of the jealous Cyril and his fanatical followers, it is not here necessary to dwell.

* Celsus, who wrote in the reign of Augustus (A.D. 1), mentions large hospitals where patients were treated with specific medicines. (Milligan's Ed., p. 14.) Seneca also refers to them as "valetudinaria."

The practice of medicine by women obtained to some extent during the Middle Ages. Under the influence of Mohammedan rule women were placed in excessive isolation, and it is not surprising to find under these circumstances that certain women were skilled in attending to the requirements of their own sex. Thus Albucasis, of Cordova, one of the most skilful surgeons of the twelfth century, secured the services of properly instructed women for assistance in operations on females in which considerations of delicacy intervened. Avicenna, also, writing of remedies for diseases of the eyes, mentions a collyrium compounded by a woman well versed in medical science. On the whole, however, the number of women instructed in medicine among the Arabs was very small, owing possibly to the inferiority to which women were condemned by Eastern usages.

In Christian countries the nuns as well as the priests attended to the healing of the sick as an act of charity and piety. Abélard, in the twelfth century, permitted the practice of surgery to those of the convent of the Paraclete, over which Héloïse presided. The most celebrated of the learned nuns was Hildegard (A.D. 1098 to 1180), abbess of the convent of Rupertsberg, near Bingen on the Rhine. She compiled a sort of *Materia Medica*, which comprises a variety of superstitious remedies. Radegonde, of France, the founder of a convent at Poitiers (died 587), the pious ascetic Elizabeth of Hungary (died 1231), Hedwigia, wife of Henry the Bearded, and other women who devoted themselves to the care of the sick, may be properly regarded as praiseworthy exemplars of Christian benevolence rather than educated practitioners of medicine.

In the famous school of medicine established at Salerno by Benedictine monks, in the eleventh century, we find women taking an important part. Ordericus Vitalis, in his "*Ecclesiastical History*" (written about 1130), relates that an abbot eminent in natural sciences, and especially distinguished in medicine, visited Salerno in the year 1059 for the purpose of discussing medical topics, and found no one erudite enough to reply to his propositions save a certain woman of great learning. This woman he does not name, but she is supposed to be the same as Trotula of Ruggiero, whose reputation at that period was world-wide. At Salerno women were engaged in the preparation of drugs and cosmetics, and in the practice of medicine among persons of both sexes: such were Abella, author of two medical poems; Costanza Calenda, the talented and beautiful

daughter of a skilful physician, under whose instructions she attained to a doctor's degree; Mercuriade, author of several treatises; Rebecca Guarna, Adelmota Maltraversa and Marguerite of Naples, who obtained royal authority for practising the medical art.—(Beaugrand, in "Dict. Encyc. Sci. Médicales.")

The ancient and honourable universities of Italy were, we believe, the first to recognise the capacity of women to give instruction of a high character. The University of Bologna, founded in 1116, was attended in the year 1250 by ten thousand students, engaged in the study of jurisprudence, of philosophy, and of medicine. "Here was first taught the anatomy of the human frame, the mysteries of galvanic electricity, and later the circulation of the blood." Here, too, were the earliest successful experiments in admitting women to occupy professorial chairs, for a long line of female professors taught in many departments of learning.*

As early as the thirteenth century two women were numbered among the eminent professors of the University of Bologna—Accorsa Accorso and Bettisia Gozzadini; the former held the chair of Philosophy, the latter that of Jurisprudence. In the fourteenth century the lovely and learned Novella d'Andrea, daughter of a distinguished lawyer, often took her father's place in the professorial chair, and instructed his students in law. Of Novella it is reported that she was so beautiful that she lectured behind a curtain, "lest, if her charms were seen, the students should let their young eyes wander over her exquisite features and quite forget their jurisprudence." The rival University of Padua, founded in 1228, had also its female representatives. Of these the most distinguished was Elena Lucrezia Cornaro. This interesting woman was born at Venice, June 5, 1646, and at a very early age exhibited an extraordinary capacity for acquiring languages. She was familiar with French, Spanish, Latin, Greek, and Hebrew, besides her native Italian, and had some acquaintance with Arabic. While endowed by nature with poetical and musical talents, she possessed at the same time great perseverance and capacity for serious studies, and discoursed eloquently on abstruse topics in philosophy, mathematics, astronomy, and theology. At the age of 32 the University of Padua conferred upon her the degree of Doctor of Philosophy. Cornaro seems

* According to Madame Villari, whose papers on the "Learned Women of Bologna" furnish us with many of the succeeding data, there is to the present day no law preventing women from graduating at Italian universities or taking professorial positions.

never to have held any public position, being naturally of a retiring disposition, and moreover exceedingly devoted to the order of St. Benedict. After acquiring a European reputation she died at the comparatively early age of 38 (1684).

The beginning of the following century witnessed the birth of one of the most gifted women the world has ever seen. Laura Caterina Bassi was born at Bologna, October 31, 1711. She was the daughter of a distinguished lawyer and *littérateur*, and at a tender age manifested extraordinary precocity, being able while still a child to translate fluently most difficult Latin and Greek. Encouraged by her father, she pursued her studies under the guidance of eminent masters; she learned physiology and medicine with the erudite physician Gaetano Tacconi, mathematics with Manfredi, and natural philosophy with the disciples of Gassendi, and she astonished these profound philosophers by her talents. Laura Bassi studied for the pure love of knowledge, and had no ambition to seek public honours, but, to gratify the pardonable pride of a father as well as the earnest desire of her instructors, she consented to support a philosophical thesis before a learned audience of professors. This event took place on the 17th of April, 1732, before she had reached the age of 21 years. The occasion was made one of festivity by the whole city, who turned out to do her honour; the assemblage was presided over by two cardinals—Lambertini, afterward Pope Benedict XIV., and Grimaldi. According to custom her thesis was opposed by seven learned men; to these she replied in elegant Latin with great success and amid the applause of the distinguished audience. A month later the degree of Doctor was conferred upon her, and she was honoured by a position in the Faculty of Philosophy. The Senate subsequently bestowed upon her the chair of Physics, and commemorated the event by striking a medal which bore her own portrait. She held the professorship twenty-eight years with marked success, paying particular attention to mathematics and physics, also to *belles-lettres*. Several academies of learning elected her to membership. In 1738 she was married to J. J. Veratti, a physician, and became in the course of time the mother of twelve children. A learned French *littérateur* who visited Bologna in her day thus describes her appearance:—"Laura Bassi has a countenance slightly marked with small-pox, but of a sweet and modest expression; her black eyes are sparkling, yet tranquil, and she is serious and composed in demeanour without affectation or vanity. Her memory is tenacious, her judgment sound, and her

imagination active." She died in the year 1778, at the age of 67.

Laura Bassi does not seem to have pursued medical studies, and certainly never engaged in practice; but any account of the gifted women of Bologna who laboured in this direction would be incomplete without a brief notice of Madame Veratti.

Contemporary with this interesting woman lived another, less gifted but scarcely less renowned. Anna Morandi was born at Bologna five years later than Lauri Bassi, and died four years earlier. She became the wife of Giovanni Manzolini, a poor, hard-working maker of anatomical models. Manzolini was an expert painter and modeller in wax, and was employed by one Lelli to construct a series of anatomical models for the use of the professors in the Institute of Bologna. Anna not only aided her husband, but soon surpassed him in skill, and particularly in that scientific knowledge upon which the success of their joint labours so largely depended. About this time Giovanni Antonio Galli, a skilful surgeon and professor of Gynecology, opened a school of obstetrics in his house, and, encouraged by him, Anna began to lecture on anatomy to private classes. In these lectures she not only imparted with peculiar talent the knowledge derived from her husband, but she also communicated many discoveries made by herself. So great was her skill in all dissections requiring delicacy of touch and minuteness of detail, and so clearly did she demonstrate, both theoretically and practically, the wonderful structure of the human body, that she rapidly acquired a European reputation, and her lecture-room was frequented by students of all countries.

In 1755 Anna Manzolini became a widow, and was left with very slender means of support, but her good qualities raised up friends who secured for her a comfortable subsistence. Though she received tempting offers from other Italian universities, and even from England and Russia, she preferred to remain in her native city, Bologna. Not long after her husband's death she was appointed to the chair of Anatomy in the Bologna Institute.

Anna Morandi-Manzolini enjoys the distinction of having been the first "to reproduce in wax such minute portions of the human body as the capillary vessels and the nerves." Her collection of anatomical models, still to be seen at the Institute of Science, bears silent testimony to her remarkable skill and accurate knowledge. "Her lectures were delivered in the fragrant cedar hall which is one of the

modern sights of Bologna, and in which Lelli's anatomical wooden figures supporting the canopy over the professorial chair attract general admiration." In the anatomical gallery of the university is to be seen her portrait in wax, modelled by herself at the request of many admiring friends. Anna Manzolini closed a laborious and honoured life in 1774, at the age of 58 years.

The city of Bologna, in the middle of the eighteenth century, saw three gifted women simultaneously occupying seats in the faculty of its ancient university. Besides Laura Bassi and Anna Morandi-Manzolini, of whom we have briefly spoken, Maria Gaetano Agnesi was equally distinguished.

Maria Agnesi was born at Milan, March 16, 1718. At an early age she manifested a remarkable facility for acquiring languages, and when only 20 years old was able to discourse in French, Spanish, German, Greek, and Hebrew, besides her mother-tongue. She displayed marked ability also in philosophy and mathematics, and while still young sustained one hundred and ninety-one theses, which were afterward printed under the title "*Propositiones Philosophicæ*." In 1748 Agnesi published a treatise on algebra, including the differential and integral calculus, in which she displayed wonderful judgment and erudition. This work ("*Instituzioni Analitiche*") was afterward translated by Colson, the Lucasian Professor of Mathematics at Cambridge, and was used by the students of that university. In 1750 her father, who was Professor of Mathematics at the University of Bologna, fell sick, and she obtained permission of the good Pope Benedictus XIV. to occupy her father's chair. In person Agnesi is said to have been beautiful, modest, and of pleasing manners. Her severe studies overtaxed her delicate frame, and shortly after she renounced the world and took refuge among the Blue Nuns at Bologna. In this nunnery she lived several years a devotee and an invalid; she died in 1799.

While Laura Bassi taught physics, Anna Morandi-Manzolini anatomy, and Maria Agnesi mathematics, in the Bolognese University, we might naturally expect the gentler sex to avail themselves of the opportunity of studying under their sisters' instructions. And such, in fact, was the case: the names of some of these students are recorded by the historian, many of whom received the degrees of Doctor of Philosophy and Doctor of Medicine. In 1799 Doctor Maria delle Donne appears as Professor of Medicine and Obstetrics; Clotilda Tambroni was Professor of the Greek

Language and Literature, from 1793 to 1808. To these names should be added those of Novella Calderini, Maddalena Buonsignori, Dorotea Bocchi (who was both doctor and professor) Christina Roccati, Ph.D., Zaffira Ferretti, M.D., Maria Segà, M.D., and numerous graduates of Padua, Pavia, Ferrara, and other Italian universities.

Leaving the Italian peninsula, which was so productive of remarkable personages, we will briefly examine the position of women practitioners of medicine in other parts of Europe.

Beaugrand states that the most ancient document extant relative to the organisation of surgery in France forbids the practice of surgeons and of *female* surgeons who have failed to pass a satisfactory examination before the proper authorities. This paper bears the date 1311. References to female surgeons appear again in an edict of King John in 1352. From these documents it appears that women exercised the function of surgeon under legal authority. At a somewhat later period we find the calling of physician followed by women in Spain, Germany, and England.

In Spain, the Universities of Cordova, Salamanca, and Alcala honoured many women with doctors' degrees. We note also the appearance at Madrid, in 1587, of a learned medical work entitled "*Nueva Filosofia de la Naturaleza del Hombre*," and published over the name Olivia del Sabuco. Of this person, however, nothing whatever is certainly known, and it has been conjectured that the name Olivia was a pseudonym assumed by some eminent physician.

In Germany many women cultivated medical science: Barbara Weintrauben was an author of no great merit; the Duchess Eleanor of Troppau, Catharina Tisshheim, Helena Aldegunde, and Frau Erxleben are deserving passing notice. The last-mentioned was one of the most successful female practitioners of the last century. Her maiden name was Dorothea Leporin, but she is best known as Frau Erxleben. Fräulein Leporin pursued her medical studies at the University of Halle, and obtained a diploma in 1734. She settled in the little town of Quedlinburg, at the foot of the Hartz Mountains, became the wife of the rector of the Church of St. Nicholas in the same place, industriously practised her profession, and became eminent for her skill and learning. Her son, J. C. P. Erxleben, inherited from his mother a love of scientific pursuits, and became a distinguished naturalist and professor in the University of Göttingen.

In England, Anna Wolley and Elizabeth of Kent were

occupied with the preparation of drugs as early as the seventeenth century, and both published works on medical subjects.

In this hasty and superficial sketch of the history of the early practice of medicine by women we would not be true to the facts if we omitted mention of certain ignorant and vulgar women who assumed medical knowledge and medical skill to impose upon a too credulous public. That avaricious women, fond of notoriety and careless of their reputation, should imitate the methods adopted in every age by unprincipled men, is not surprising, though it may be mortifying. To this class belonged Louise Bourgeois, nurse to Marie de Medici, the Queen of Henry IV. of France: though an ignorant charlatan, she acquired extraordinary influence over her royal patroness, and her career abounds in curious eventful episodes. She was the author of several medical treatises on the diseases of women, one of which was published at Paris in 1617.

A century later another female practitioner flourished, of whom women have no reason to be proud. In the year 1738 Mrs. Joanna Stephens proclaimed in London that she had discovered a sovereign remedy for a painful disease. Notwithstanding her gross ignorance and vulgar demeanour she secured a large circle of patients from among the upper and wealthy classes, and, after enriching herself by enormous fees drawn from their credulity, she proposed to make her medical discovery public in consideration of the modest sum of twenty-five thousand dollars. A subscription was started for this purpose and enthusiastically taken up; the clergy, lords, and ladies, with an inexplicable infatuation, hastened to add their names to the list of subscribers. Failing, however, to raise so large a sum of money, Mrs. Stephens's friends obtained a grant of the desired amount from Parliament. The certificate testifying to the "utility, efficacy, and dissolving power of the medicines," bears the date March 5, 1739, and is signed by twenty justices. These dearly purchased remedies were three in number, "a powder, a decoction, and pills." The powder consisted of calcined egg-shells and snails; the decoction was a disgusting mixture of herbs, soap, and honey, boiled in water; and the pills were made of "calcined wild-carrot seeds, burdock seeds, ashen keys, hips, and haws—all burned to a blackness—soap, and honey."

Contemporary with Mrs. Stephens lived another impostor, Mrs. Mapp, sometimes known as "Crazy Sally of Epsom," and described as an "enormously fat, ugly creature,

accustomed to frequent country fairs, about which she loved to reel, screaming, abusive, and in a state of beastly intoxication." This attractive lady was by profession a bone-setter, and was patronised by patients of rank and wealth, who sought her charily bestowed favours with ill-disguised contempt of her person. The town authorities of Epsom greatly esteemed Mrs. Mapp, or perhaps we should say highly valued the benefit the town derived from the influx of wealthy patients, and they offered her the sum of five hundred dollars per annum if she would continue to reside in the town.

The first half of this century has witnessed the career of a few women eminent in the art of healing. In France Madame La Chapelle had an extensive gynecological practice, and Madame Boivin attained to such distinction that she was honoured with the degree of Doctor of Medicine by the University of Marburg. In Germany Charlotte Heidenreich and Frau Heiland, her step-mother, were similarly honoured with doctors' diplomas.

It is the glory of America that she is distinguished above all countries not only as the cradle of liberty, but also as the foster-mother of the intellectual advancement of women. Yet this has not always been the case: in the early chronicles of the colonists (themselves refugees from persecution) we find, strangely enough, many laws of an exacting and repressive character, some of which were aimed directly at the ambition and zeal of women. In the famous Blue Laws of Connecticut the following curious entry occurs under the date of March, 1638:—"Jane Hawkins, the wife of Richard Hawkins, had liberty till the beginning of the third month called May, and the magistrates (if shee did not depart before) to dispose of her; and in the mean time shee is not to meddle in surgery or phisick, drinks, plaisters, or oyles, nor to question matters of religion except with the Elders for satisfaction."—"True Blue Laws of Connecticut," by J. H. Trumbull, 1876.)

A hundred and forty years later we find marked progress in liberality in the State of Connecticut. As early as 1773, in the town of Torrington, Litchfield County, two women were greatly honoured and much sought for on account of their remarkable skill as accoucheuses. The first of these, Mrs. Jacob Johnson, to quote the historian of Torrington (Rev. Samuel Orcutt), was as thoroughly known and trusted in her profession as any physician that was ever in the town. "She rode on horseback, keeping a horse for the special purpose, and travelling night and day, far and near,"

to meet her engagements. "She kept an account of the number of cases she had, and the success of the patients, and the new-comers, and of these last there is at least one living in the town. In the midst of her usefulness she was removed by death, and it became a great inquiry, 'Who will take the place of Granny Johnson?'" This question was answered more successfully than anticipated in the person of Mrs. Huldah Beach, daughter of Aaron Loomis, jun. Mrs. Beach became as celebrated in her calling as Granny Johnson, and continued to attend to her professional duties until an advanced age. She was a woman of remarkably fine personal appearance and decided dignity of carriage, yet marked kindness of manner. Her intellectual strength and ability was perceptible to every one, and she in consequence commanded great respect in all classes of society, and won the confidence of the people so that but few calls were made on any other physician in her specialty, on the western side of the town. She also rode as far as Winchester, Goshen, and Litchfield.

Dr. Orcutt, whose "History of Torrington" has furnished us with these particulars, remarks in this connection—"Many have imagined that, in the practice of medicine by women, a new era has arrived, but in this there is only a 'restoration of the lost arts.'"

Our allotted task is completed, yet we cannot close this address without a brief survey of the present period, in which the facilities afforded women in all branches of learning contrast strongly with the impediments and obstacles formerly well nigh insurmountable.

Women desirous of acquiring medical knowledge are no longer obliged to disguise themselves in male attire like Agnodice the Athenian, nor are practitioners liable to suffer the penalties of the law for their works of benevolence and charity. In 1880 the young woman with aspirations for intellectual culture finds open to her such excellent training-schools as Holyoke, Wells, and Rutgers,—such noble institutions as Vassar, Smith, and Wellesley. Does she not shrink from contact with her brothers, she may gain entrance into many universities, either expressly founded in a liberal spirit,—as Oberlin, Cornell, and Ann Arbor,—or which have yielded to the steady pressure of public opinion, and now open their doors more or less widely to the gentler sex. To enumerate the latter would be tedious and unprofitable; suffice it to say that even venerable and aristocratic Harvard has lately joined the number, and our own Columbia, should her President's views prevail, will not be slow to follow.

The young woman who seeks intellectual training of a more technical character, with a view to adopting a professional career, will find many avenues opening up with constantly increasing privileges and facilities. The student in art, thanks to the philanthropy of our venerable citizen, Peter Cooper, can, without incurring expense, acquire a knowledge of designing or of wood-engraving which will hardly fail to secure for her a competence. The student in biology will receive her share of attention at a summer school of science on our Atlantic seaboard, or held in connection with some enterprising institution of learning. The student in pharmacy and chemistry can conduct her researches on an equality with men, or, if she prefer, in laboratories controlled and officered in large part by women themselves.

The student in medicine now gains access to medical colleges in nearly every State in the Union, and the legitimacy of her pursuit as well as her ability to grapple with it gain increasing advocates. "She is no longer regarded as too good and too stupid to study medicine." The candidate for medical honours also finds in Boston, Philadelphia, New York, and Chicago, well-appointed schools of medicine especially adapted to her needs, with corps of trained and sympathising instructors ready to lend a helping hand.

Looking across the Atlantic, we find countries so lately intolerant of the intellectual advancement of woman at last yielding, not always gracefully, to the inevitable. The little republic of Switzerland, and the mighty empire of Russia have for many years manifested practical sympathy with the cause; and now, slowly yet surely, conservative England begins to recognise the fact that the Anglo-Saxon race, with its boasted love of liberty, has been neglectful of its duty to womankind.

To trace any more fully the history of the recent period does not fall within the province of our address; we look to the pioneers of this movement who are still with us, for an exhaustive and authentic record such as participators and eye-witnesses alone can supply.



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ANCIENT METHODS *copy*
OF
FILTRATION.

BY
H. CARRINGTON BOLTON, PH. D.,
PROFESSOR OF CHEMISTRY IN TRINITY COLLEGE, HARTFORD.

[Reprinted from THE POPULAR SCIENCE MONTHLY, February, 1880.]

NEW YORK:
D. APPLETON AND COMPANY.
1880.

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ANCIENT METHODS OF FILTRATION.*

THE separation of a liquid from solids suspended in it, by straining through some material pervious to the one and impenetrable to the other, was a familiar process in the remotest antiquity. Observation of various processes in nature, such as the purification of water by trickling through sandy soil, or perhaps the accidental passage of rain-water through an outstretched cloth, a garment, or a tent-cover, would obviously suggest the simple expedient. History fails to record the period of the invention or the name of the individual who first put it in practice. Etymological considerations show that filters were early made of fulled wool or felt; the Latin *filtrum*, "a filter," being closely connected with *feltrum*, "felt," or compressed wool, and both are related to the Greek *πίλος*, signifying hair.

Several writers on the history of science make casual reference to the operations performed by the early chemists: some state in a general way their acquaintance with the processes of distillation, sublimation, filtration, etc.; others are more explicit. Hermann Kopp, in his exhaustive "Geschichte der Chemie,"† states that "filtration as a chemical process was first accurately described by Geber, who calls it by a special name, *destillatio per filtrum*, 'trickling through a filter,' in contrast to the collection of a liquid by ordinary distillation." Ferdinand Hoefer, in his "Histoire de Chimie"‡ writing of Geber, mentions that he recognizes two kinds of distillation—with and without fire—the former being "*per alembicum*," and the latter consisting of "une simple filtration."

Now, we propose to show that the ancients carried on the operation of filtration in two ways, essentially distinct in principle and in the manner of execution, and that these methods were characterized by two different expressions which have been confounded by the authors

*Read before the New York Academy of Sciences, October 13, 1879.

† Vol. ii., p. 26.

‡ Vol. i., p. 335.

named. Moreover, we shall establish this by quotations from writings covering a period of more than two thousand years.

In the first place, an examination of the very passage in Geber's Works, referred to by Kopp and by Hoefer, shows that the method therein described differs radically from filtration as ordinarily conducted at the present time. We quote the passage as found in the works of Geber, "the most famous Arabian Prince and Philosopher," "faithfully englished by R[ichard] R[ussell]," and printed at London in 1678. In the thirteenth chapter of the fourth part of the first book of the "Summe of Perfection," Geber treats of the three kinds of distillation: by an "Alembick," by a "Decensory," and "by Filter." After describing in quaint language the well-known method of using the alembic and the decensory (which differs chiefly in the application of heat on the top of the apparatus), Geber writes thus of filtration: "The *Disposition* of that which is made by *Filter* is, that the *Liquor* to be *Distilled* be put into a *Stone Concha*, and the wider part of the *Filter* put into the said *Liquor*, even to the *Bottom* of the *Concha*, but the narrower part of it hang out over the *Orifice* of the said *Vessel*. And under that end of the *Filter* must be set another *Vessel* for receiving the *Distillation*. Therefore when the *Filter* begins to *Distill*, the *Water* with which it was moistened will first *Distill* off; which ceasing, the *Liquor* to be *Distilled* succeeds. Which *Liquor*, if it be not as yet serene, it must so often be put into the *Concha* again and redistilled, as until it be *Distilled* most serene."

This dates from the eighth century, and evidently describes a sort of capillary siphoning. The expressions "placing the wider part of the filter" into the liquid and allowing the "narrower part of it to hang out over" the vessel admit of no other interpretation. For convenience of distinguishing this method of filtration from that in which porous sacs are employed, we propose to name the former *anethisis*, a word made from *ἀνά*, "upward," and *ἡθισις*, "a straining off." A study of the chemical works of the middle ages further shows that the expression "*destillatio per filtrum*" is invariably used to describe *anethisis*, while "*filtratio*" is applied to ordinary filtration. We shall give quotations proving this, but first make brief reference to early records.

The ancient Egyptians portray in the rock-cut memorials the operation of filtration in connection with the manufacture of wine. Their simple wine-press consisted of a bag in which the grapes were placed, and squeezed by means of two poles turned in contrary directions. Small colanders of bronze have been found at Thebes. Views of the interior of an Egyptian kitchen, cut in the tomb of Rameses III. at Thebes, represent siphons in use for drawing off liquids of various kinds. (Wilkinson.) The ancient Romans employed strainers and colanders (*colum*) made of a great variety of materials. Wine-strainers were made of silver and bronze; the poorer classes used linen, and,

where nicety was not required, they used those made of broom or of rushes. Strictly speaking, however, percolation through colanders is not filtration, for capillary action plays no part.

It is interesting to note that the earliest mention of filtration which a brief search has disclosed refers to the method we have ventured to call *anethisis*. This occurs in Plato's "Symposium," written about four hundred years before the Christian era; the passage is as follows: "Socrates then sitting down, observed, 'It would be well, Agatho, if wisdom were a thing of such a kind as to flow from the party filled with it to the one who is less so, when they touch each other, like water in vessels running by means of a thread of wool from the fuller vessel into the emptier.'"^{*}

Aristotle, the pupil of Plato, in his essay "De Generatione Animalia," refers to the other process in the following words: "Flesh is produced, therefore, through the veins and pores, the nutriment being deduced in the same manner as water through earthen vessels not sufficiently baked."

This passage, together with others occurring in Plato, shows that both systems of filtration were employed at that early period.

Geber, whose clear description of *anethisis* we have quoted, was followed by the celebrated Arabian physician, Rhazes; he uses the same expression, "*destillatio per filtrum*," in the following passage: "Dissolve as much [common salt] as you wish in five times as much warm soft water, and distill per filtrum and congeal [i. e., crystallize]."† Rhazes died about 930 A. D.

Among the early writers on alchemy, no one is oftener quoted than Raymund Lulli, surnamed the Enlightened Doctor (born 1235, died 1315 A. D.). In his works we find the following characteristic passage: "Take, in the Name of God, great Bay Salt, as it is made out of the Sea; take a good quantity and stamp very small into a stone-mortar: then take Cucurbites of Glass and pour your Salt therein: then take fair Well-water, and let your salt resolve into cleer water; being all dissolved then distil it by Filter; that is to say, hang a jag Felt or Woolen cloath in the Cucurbite; and let the other end hang in another Glass beside it, set as it were under it, that the water may drop into it that the Felt or Cloath may draw out and that shall be cleer as silver."

This unmistakable description of *anethisis* occurs in the first chapter of a booklet bearing the following title: "Philosophical and Chymical Experiments of the Famous Philosopher Raymund Lulli . . . wherein is contained . . . the admirable and perfect way of making the great Stone of the Philosophers as . . . sometimes prac-

^{*} Plato's works, Burges's translation, vol. iii., p. 480 (Bohn).

† "Collect. ex Rhasi in Margarita Pretiosa Novella" of Petrus Bonus (1330), Venetia, 1546.

tised in England by Raymund Lulli in the time of King Edward the Third." London, 1657.

Thomas Aquinas, the eminent scholastic teacher of the thirteenth century, who is best known by his theological and metaphysical works, also paid some attention to scientific pursuits, possibly acquiring this taste from his learned master, Albertus Magnus. Aquinas, or the divine Thomas, as he was called by his admirers, defines distillation to be the "purification of waters falling drop by drop, and effected by placing a filter cut in the shape of an iron dart in the little dish containing the water to be distilled." *

Libavius, in his remarkable work, "Alchymia," sometimes called the first text-book of chemistry (published in 1595), devotes two entire chapters to the subjects of distillation and of filtration.† In the fourteenth chapter he describes, with much attention to detail, the manner of filtering by means of pieces of felt (*lucinia*) shaped like an ox-tongue, the broader portion of which is placed in the vessel containing the liquid to be filtered, and "the apex in the recipient, or, if the vessel has a narrower neck, in a suitable funnel." This demonstrates that the method was not resorted to on account of the want of proper funnels, and suggests that perhaps a special virtue was attributed to a liquid thus purified.

Libavius's work contains rude woodcuts illustrating different methods of procedure. For perfecting the purification a series of four vessels was used. These were placed on steps, one above another, and the liquid passed through a capillary siphon from the uppermost to the one immediately below, and thence by another siphon to the third vessel, and so on to the fourth. This series of vessels can be inclosed in a glass-covered box for filtering volatile liquids. Another woodcut represents the lower end of a capillary siphon hanging into a funnel inserted in the neck of a flask. The method thus clearly portrayed is called *destillatio per lucinias*, and is evidently regarded as a process of distillation; ordinary filtration through porous stones and through bibulous paper is treated in another and following chapter.

Libavius makes reference to "Hippocrates's Sleeves,"‡ by which name were designated conical felt bags used in filtration.

Sir Robert Boyle, in his "Experiments touching the Spring of the Air," writes as follows: "Some learned mathematicians have of late ingeniously endeavored to reduce filters to siphons, but still the true cause of the ascension of water and other liquors, both in siphons and

* "Pretiosa Margarita Novella" of Petrus Bonus (1330), Venetia, 1546.

† "Comment. Alchymia," Part I., lib. iii., edition 1606.

‡ The origin of this curious term we have been unable to discover, nor is it of common occurrence in early writings on chemistry and pharmacy. The only explanation of the expression which we have as yet found occurs in the "*Lexicon novum Medicum Græco-Latinum*" of Stephen Blancardus, published in 1702. This author writes as follows: "*Manica Hippocratis* est sacculus laneus figura pyramidalis, quo vina aromatica et medicamentosa, aliique liquores percolantur; ex *υπο σιβ* et *κεραυου μινisco*."

in filtration, [requires] a clearer discovery and explication."* And in another place he gives this "explication": "The parts of the filter that touch the water being swelled by the ingress of it to their pores are thereby made to lift up the water till it touch the superior parts of the filter that are almost contiguous to them; by which means, these being also wetted and swelled, raise the water to the other neighboring parts of the filter till it have reached the top of it, whence its own gravity will make it descend."†

These passages can only apply to anethisis, which was apparently a common method of filtration in Boyle's day.

Again, to trace this process still later, Juncker, in his "Conspic-tus Chemiæ," published in 1730, describes seven kinds of filtration. These differ chiefly in respect to the materials used: two methods, however, are essentially distinct; the one is styled "*filtratio per chartam bibulam . . . in fundibulo vitreo*" (filtration through bibulous paper in a glass funnel), and the other is described in the words "*per segmentum panni lanci vel laciniam bombycinam vel funiculos gossypii*" (through shreds of woolen cloth, silken threads, or through little strings of cotton).

Our friend Professor S. A. Lattimore sends us another reference to this process from "The Laboratory or School of Arts, etc., compiled by G. Smith, sixth edition, London, 1799" (vol. i., p. 435); the passage is as follows:

"*To separate Water from Wine.*—Put into the cask a wick of cotton, which should soak in the wine by one end and come out of the cask at the bung-hole by the other; and every drop of water which may happen to be mixed with the wine will still out by that wick or filter."

Thus we see that, so recently as the close of the last century, anethisis was accounted a practical method of filtration.

We have not found this method in Boerhaave (1727), nor in Lemery (1675), nor does Faraday, in his "Chemical Manipulations," make any allusion to it. As a process of purification of solutions, it seems to have been lost sight of in modern laboratory practice.

We have made trial of the method rendered noteworthy by more than two thousand years' practice, and find that, while the process is quite slow, it has certain advantages. Chief among these is the fact that, when the capillary siphon is adjusted, it requires no further attention; there is no pouring into a constantly emptying funnel, and there is no possibility of overflow. When properly arranged, the last drop of liquid passes from the upper vessel to the lower, and, except in certain cases of extreme divisibility, the filtration is perfect. The process seems particularly adapted to the purification of weak solutions, as of mineral waters, where the insoluble portion is not to be conserved. There is obviously much choice in the material of which

* Boyle's Works, London, 1772, vol. i., p. 79.

† Idem., vol. iii., p. 233.

the capillary siphon is made. We have tried cotton, wool, lamp-wick, and asbestos, and we find stout, silky wads of the latter most serviceable; it is also useful for filtering very acid and alkaline solutions.

The rapidity of filtration does not seem to be hastened by lengthening the longer arm of the siphon, and is chiefly dependent on the number of threads in the filter, and on their fineness. In one experiment, thirty-two strands of cotton yarn filtered twice as fast as sixteen strands, and only half as fast as sixty-four strands. Oil filters much slower than saline solutions, and the latter much slower than pure water.

We have used the expression "capillary siphoning" in describing anethisis, and perhaps it needs justification. The ascension of the liquid is due to capillarity, and the descent through the longer arm of the siphon is in obedience to gravity. Siphoning is dependent on atmospheric pressure, and can not be strictly applied to the present case; yet we find by experiment that, if the lower arm of the woolen threads be raised to the level of the liquid to be filtered, the action ceases, and the form of a siphon is at all events essential to the process.

The quotations from ancient authors show that they must have been quite familiar with capillary attraction, yet the first observance of this phenomenon is attributed by some authorities to Franciscus Aggiunti, physician to the Grand Duke of Tuscany, about the beginning of the seventeenth century.* (Aggiunti died 1635.)

In conclusion, the object of this paper is not to propose a return to this ancient method of filtration, the modern rapid processes being more in accordance with present needs; but we have thought it not altogether useless to call attention to a neglected process which can in certain cases be employed with advantage. Where the object of filtration is to collect the insoluble portion, it is obviously of no value; whether the process could be advantageously used on a large scale remains to be tested.

* Gehler's "Physikalisches Wörterbuch," article "Capillarität."

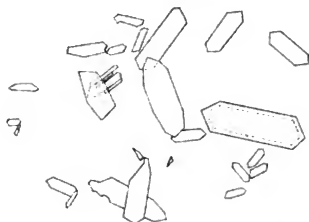
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OCCURRENCE
OF
MICROSCOPIC CRYSTALS
IN THE
VERTEBRÆ
OF THE
TOAD.

H. CARRINGTON BOLTON.

Fig.1 (RANA)



$\times 900$ diam.

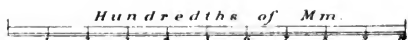


Fig.2. (Suro)

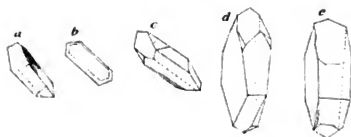
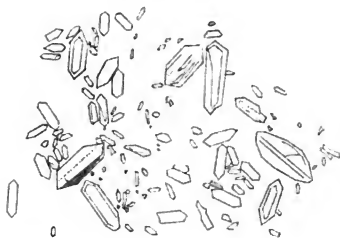
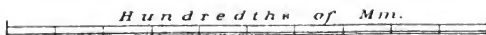


Fig.3. (Suro)



$\times 1008$ diam.



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ON THE OCCURRENCE OF MICROSCOPIC CRYSTALS IN THE VERTEBRA OF THE TOAD (*Bufo Americanus*). By H. CARRINGTON BOLTON, of Hartford, Conn. WITH A NOTE BY ALEXIS A. JULIEN, of New York.

THE microscopic crystals contained in the capsules attached to the spinal nerve of the frog have been examined by many Histologists. They were first noticed, we believe, by the learned Flemish physician, BLASIUS¹ in the latter part of the seventeenth century. SWANN, in his *Comparative Anatomy of the Nervous System*,² gives figures of them without any detailed description, and Wagner³ refers to the crystals as follows: "The ganglia admit of being very readily demonstrated, lying upon the sides of the vertebral column; they are situated near those small white vesicles which protrude by becoming swollen, chiefly during the

¹ Anat. Animalium, Amst. p. 291, 1681.

² Plate VII, figs. 5 and 6.

³ Comp. Anat. Vertebrates, part I., p. 151.

spring of the year, and contain numerous microscopic calcareous crystals." They were also observed by Stannius and by Prof. Owen, who, however, added little to our knowledge of them.

In 1852 Dr. Jeffries Wyman prepared a memoir on the "Anatomy of the Nervous System of *Rana Pipiens*," which is published in the fifth volume of the Smithsonian Contributions to Knowledge, (1853). In this paper he states that the "crystal capsules are subject to some variety, but exist on the trunks of all the true spinal nerves, the hypoglossus included, and invest them more or less completely at their exit from the spinal canal, occupying the space between the transverse processes of two adjoining vertebræ. The capsule is a very thin membrane, sometimes having a diameter of 2 to 3 lines; its surface is minutely lobulated in appearance, which results from the existence of numerous partitions within, forming many small cavities, which communicate, though not very freely, with each other. The contents of these pouches are vast numbers of exceedingly minute crystals of a somewhat oval form, pointed at their extremities, and comparable in shape to a lemon seed, but sometimes presenting well defined angles."

Dr. Wyman failed to confirm Wagner's statement that the capsules are more swollen in the spring of the year, having, he says, "detected them of nearly equal dimensions at all seasons," and he also differs from Stannius in regarding them as characteristic of the adult animal.

Dr. Wyman then remarks: "Dissections of other than Rani-form Batrachians have not led to their detection; I have not found them in *Siren*, *Menobanchus*, *Bufo* or *Salamandra*, but have seen them in *Rana fontinalis*, *Rana hulecina* and *Rana palustris*. They seem to be in these species constant appendages to the spinal nerves."

Notwithstanding this positive statement of so distinguished and accurate an observer, the writer has found the microscopic crystals in the toad in great abundance, and differing little in form and general appearance from those occurring in the frog. Specimens of the common toad (*Bufo Americanus*), collected both in the autumn and in the spring were dissected, and in every instance the contents of the spinal canal examined under a $\frac{1}{8}$ inch objective, disclosed the white matter as a mass of minute crystals.

On treating the crystals on a glass slide with acetic acid they

dissolve with effervescence, and the addition of oxalate of ammonium to this solution produces a milkiness visible to the unaided eye, which under the microscope appears to be formed of minute ovoid masses characteristic of precipitated calcium oxalate.

When the calcareous crystals are placed under the microscope in a drop of water, they exhibit in a marked manner the phenomena known as Brownian motions; the larger crystals remain at rest but the smaller ones having a length of about $\frac{1}{1000}$ millimetre maintain a constant restless motion. That similar crystals from the spinal canal of the frog exhibit this phenomenon is well known to histologists.⁴

The resemblance of the crystals from the toad to those from the frog is very close, but a careful examination shows that the former average somewhat smaller than the latter. Slides containing crystals from *Rana* and *Bufo*, mounted in Canada balsam, were submitted for accurate measurements to my friend, Mr. Alexis A. Julien, to whom I am greatly indebted for a painstaking examination.

Mr. Julien reports as follows:

"The crystals appear perfectly colorless with sharp outlines and with a refractive index so nearly that of the Canada balsam in which they are mounted that it is difficult to distinguish any but their outer edges. It will be seen by the measurements given below that the average size and the variation in size of the *Bufo* crystals are the greater of the two. In the accompanying sketch, Fig. 2, *d*, represents one of the larger of these crystals, exhibiting most distinctly the highly modified edges. In both the *Rana* and the *Bufo* crystals many were observed which at first glance displayed a curved or spindle-shaped outline tapering rather suddenly toward either end; some of these are shown in Figs. 1 and 3. They are often of considerable size and by careful focusing these curved outlines were found to consist of a succession of straight edges, indicating simply a more highly modified form of the common crystals. On the whole the crystals of both *Rana* and *Bufo* appear to me to differ from the otoliths of aragonite enclosed in the human ear, familiar to histologists, and to resemble rather highly modified rhombohedra of calcite belonging, perhaps, to the type represented in Fig. 553 of Dana's System of Mineralogy. No twins were anywhere observed."

⁴ Frey's Microscopical Technology, translated by Dr. Geo. R. Cutter, p. 101 (1872).

Size of Crystals in fractions of millimetre.

<i>Bufo.</i>	Length.	Breadth.
Largest	0·033	0·0140
Smallest	0·0005	0 0003
Common size	0·0034 to 0·025	0·001 to 0·01.
<i>Rana.</i>		
Largest	0·0229	0·0074
Smallest	0·0007	0·0004
Common size	0·0068	0·0014

[Otoliths measure about 0·012 mm. long by 0·008 mm. broad.⁵]

The accompanying figures from drawings by Mr. Julien show the crystals as seen with a magnifying power of 900 to 1008 diameters, under the camera lucida.

Fig. 1 shows a portion of the field seen in the slide of *Rana* crystals and Fig. 3 shows the same in that of *Bufo*, with the usual intermixture of perfect crystals and irregular fragments. Fig. 2 contains several individual crystals enlarged in the drawing.

POSTSCRIPT. — MAY, 1880.

SINCE preparing the foregoing notes Mr. Simon H. Gage, Instructor in Physiology at Cornell University, has had the kindness at my suggestion to extend the examination for calcareous crystals to other Amphibia. He reports as follows:

"Alcoholic specimens of *Siren* and *Menopoma* were very carefully examined, but no crystals could be found either in the neural canal or on the spinal nerves. A fresh *Menobranchius* was examined with the same result."

Mr. Gage confirms our observation as to the occurrence of the crystals in *Bufo* and in this connection remarks:

"In *Rana* the crystals on the nerves are beyond, peripheral of, the ganglion and seem to have no connection with those lining the neural canal; while in *Bufo* the ganglion is completely surrounded by a cushion of crystals which seem to be merely a lateral extension through the intervertebral foramina of the general cushion lining the neural canal.

Dr. Wyman in the paper quoted makes no reference to the crystals in the neural canal of *Rana*."

Mr. Gage's communication is accompanied by a cross-section of the spinal column of *Bufo* showing the exact position of the cushion of crystals, and we regret that circumstances prevent a reproduction of his sketch.

⁵ Dr. J. B. St. John Roosa in *Diseases of the Ear*, p. 475 (1874).

(13)

Bolton, H. C.

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"THE GOLD MAKERS OF THE MIDDLE AGES,"

A Lecture by

DR. H. C. BOLTON,

Monday, April 17th, 1882, 7:45 P. M.,

Under the auspices of the

⊗ Young People's Association ⊗

OF THE

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The Philosopher's Stone and how to use it.

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Portraits of early alchemists and views of
their workshops.

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Albertus Magnus, the scientific Bishop.

Raymond Lully, the gold-maker and Christian Martyr.

Nicolas Flamel and his wife, the Parisian alchemists.

Basil Valentine, the noted author.

Paracelsus, the quack.

RUDOLPH II., of Germany, the Royal Patron of Gold-
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Impostor; John Dee, the English Astrologer;
Michael Maier, the German Physician.

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CHEMICAL LITERATURE.

AN ADDRESS

DELIVERED BEFORE THE
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE,
AT MONTREAL, AUGUST 23, 1882.

BY
PROF. H. CARRINGTON BOLTON, PH. D.
VICE PRESIDENT.

SALEM:
AUTHOR'S EDITION.
1882.

With compliments of

H. Carrington Bolton, Ph. D.

TRINITY COLLEGE,
Hartford, Conn.

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1882, Oct. 10,

ent-
The Boston.

ADDRESS

BY

H. CARRINGTON BOLTON,

VICE PRESIDENT, SECTION C.

FELLOW MEMBERS OF THE CHEMICAL SECTION;

Ladies and Gentlemen :—

THE recognition by the Association of the equal rights of chemical science and the elevation of the late "Permanent Subsection" to the dignity of a "Section of Chemistry," now assembled for the first time, mark an important epoch in the annals of our organization. Permit me to offer congratulations on our promotion and to express my high appreciation of the honor of presiding over your deliberations.

The Permanent Subsection of Chemistry was organized at the Hartford meeting of the Association in 1874. It had its origin in the action of a number of chemists assembled at Northumberland in August of the same year to commemorate Priestley's discovery of Oxygen. At that memorable gathering a discussion of the advantages of forming an independent organization in the interests of chemistry led to the appointment of a committee* "to co-operate with the American Association for the Advancement of Science at their next meeting, to the end of establishing a chemical section on a firmer basis."

This committee met at Hartford a few weeks later and united with the chemical members of the Association in founding a Per-

*The committee consisted of Profs. Silliman, Smith, Horsford, Hunt and Bolton.

manent Subsection in accordance with the provisions of the new constitution adopted at the same meeting. Meetings of the subsection were held on two days and arrangements were made for its permanent organization. In the following year the Association met at Detroit and the Subsection re-assembled under the chairmanship of Prof. S. W. Johnson. Before adjourning the section elected Prof. Geo. F. Barker chairman for the ensuing year and passed a resolution requesting the chairman-elect to prepare an address. This was the origin of the custom which it is my pleasant duty to follow. Professor Barker accepted the task and his masterly essay on the Atom and the Molecule (1876) is remembered by many in this audience. Since then Prof. F. W. Clarke (1878) has urged in your hearing the endowment of laboratories of research; Prof. Ira Remsen (1879) has magnified the claims of his chosen field of investigation—organic chemistry; and Prof. J. M. Ordway (1880) has gracefully surveyed the experiences of the past, the needs of the present and the prospects of the future of chemistry.

The amendments to the Constitution, adopted by the Association at the Cincinnati meeting, provide, as you are aware, for nine sections, each with its own presiding officer; since this may involve an equal number of annual addresses, it is hardly to be expected that each will maintain the elaborate character of those of former years.

I ask you therefore to bear this fact in mind while I invite your attention to a rather superficial survey of

CHEMICAL LITERATURE.

The literature of chemistry, extending as it does through a period of more than fourteen centuries, varies greatly in character, in province and in design; it partakes of the peculiar phases exhibited by the science at different epochs and depicts the experiences and thoughts of those who cultivated it in all ages. It may be studied from several points of view: the biographer searches the voluminous records to acquire knowledge of the intellectual activity of individuals; the historian unfolds the progress made by the science in a special field or in its entirety, with philosophical inquiries respecting effects and causes; the bibliographer, scarcely penetrating beyond the title pages of the dusty tomes, laboriously catalogues them to facilitate the researches of others.

We do not propose to give you a biographical, an historical or a bibliographical treatise, but rather to review chemical writings as sources of information and as portions of the world's literary productions. We shall concern ourselves less with the questions what were the personal history and life-work of a given author, and more with the queries what are the characteristics of the various classes of works at different epochs, what discoveries do they chronicle and what was their influence on the contemporaneous science.

The very earliest information concerning chemical arts comes to us from that ancient nation supposed by some to have given its own name to the science itself; not only do the sculptured tombs and temples of Egypt portray with unimpeachable authenticity and wonderful accuracy the technical skill of that venerable people, but these same monuments are even now relinquishing their hold on long-buried treasures in the form of papyri, whose perplexing script no longer conceals their meaning from the erudition of Egyptologists.

Of these miraculously preserved papyri the most valuable to chemistry is that discovered by Prof. George Ebers at Thebes in 1872, and named after its learned discoverer. We have described this elsewhere¹ and shall not here enter into details. It is the most ancient medical work extant, being assigned to the sixteenth century B. C., and contains a vast amount of information on the medical practice and the pharmaceutical preparations at that remote period. The unknown author wrote less obscurely than many of a much later date, and when the whole papyrus shall have been deciphered it will prove an invaluable contribution to chemical history.

The most ancient manuscript treating exclusively of chemical operations is a Greek papyrus of Egyptian origin preserved in the Library of the University of Leyden. Its authorship is unknown, its date is placed by Reuvens in the third or fourth century A. D. This MS. consists of a collection of prescriptions and receipts for conducting various operations in metallic chemistry, such as the testing of gold and silver; the purification of lead, of tin and of silver; the hardening of tin and of silver; the albugification of copper, etc. It deals little with alchemy though some of the receipts evidently refer to transmutations, as those entitled: "the prepara-

tion (artificial?) of silver;" "the preparation of gold;" "the purification of tin by silver," etc.

Reference is made to sandarach (realgar), cadmia (zinc ore), chrysocolle, cinnabar, natron (soda), mercury and other chemical substances, but no receipts are given for their preparation. The author quotes from the *Materia Medica* of Dioscorides who probably preceded him by about two centuries. It is to be regretted that the full text of this ancient manuscript has never been published; the little known of it foreshadows information of great interest.²

The great libraries of Paris, Rome, Venice, Milan, Escorial, Cracow, Gotha, Munich and Cologne preserve a large number of Greek alchemical manuscripts of unknown authorship and uncertain date. Hoefer, the French historian of chemistry, refers them to the third and fourth centuries,³ but other authorities with greater probability place them not earlier than the tenth and eleventh.⁴

The most celebrated of these essays are attributed to Zosimus, of whose history nothing is certainly known, and bear these titles: "On Furnaces and Chemical Instruments," "On the Virtue and Composition of Waters," "On the Holy Water," "On the Sacred Art of Making Gold and Silver." In a treatise attributed to Synesius, we find a description of a hydroscopticum or hydrometer which was rediscovered as long after as the sixteenth century.

In a treatise attributed to Olympiodorus, he cites as authorities Democritus, Anaximander, Zosimus, Pelagius, and Marie a certain Jewess whom the later alchemists confounded with Miriam, Moses' sister.

In these manuscripts chemistry is called the "sacred art" and the exceedingly obscure and figurative language in which they are written makes it well nigh impossible to separate fact from fancy; Hoefer has indeed attempted to discover modern chemical conceptions in the allusions to Egyptian myths and the chaotic collections of spagyric arcana.

Of systematic nomenclature there is absolutely no trace; indeed each author seems to have aimed to write treatises intelligible only to himself, and we greatly doubt his success in even this respect. "Cadmia," we are informed, "is magnesia," and "magnesia is the female antimony of Macedonia;" "nitre is white sulphur which produces brass;" equally clear is the statement that the

"apospermatism of the dragon is the mercury of cinnabar." That lexicons were early in demand is not surprising; in fact some of the most ancient MSS. are "vocabularies of the sacred art," but even with their assistance it is difficult to form satisfactory concepts of contemporary chemical science.

Suidas,⁵ a Greek lexicographer of the eleventh century, states that Diocletian having conquered the rebellious Egyptians (296 A. D.) destroyed their books on the preparation of silver and gold, lest becoming rich by the practice of that art they might again resist the Romans. Regrets at the wanton acts of this imperial biblioclast are tempered by the reflection that modern scholars are spared the study of such literary absurdities.

The Chinese, that curious people who always claim a hearing when the origin or antiquity of arts and sciences is under consideration, were acquainted at a very remote period with many branches of chemical technology. We do not know of any special chemical literature produced by them, but the researches of Rev. Joseph Edkins⁶ and of Dr. W. A. P. Martin⁷ make it highly probable that scholars will yet discover contributions of no small importance to the early history of chemistry. Prof. George Gladstone⁸ has endeavored to show that the Chinese originated the doctrines and pursuit of alchemy and communicated it to the Arabs by whom it was disseminated throughout Europe.

The high state of civilization and extraordinary intellectual development of the Arabians has left a deep impression on chemical science. Cultivated chiefly by physicians, attention was directed to its pharmaceutical applications, and in spite of the prohibitions of the Koran to the fascinations of alchemy. Of their extant writings, preserved in European libraries, only a portion have been edited; those best known partake of the poetical imagery and hyperbole characteristic of the Oriental mind. This is shown to some extent in the singular titles prefixed to their treatises, *e. g.*, "The Rise of the Moon under the Auspices of Golden Particles," by the alchemist Dschildegî; "A poem in the Praise of God, of Mahomet and of Alchemy," by Dul-nun-el-Misri.⁹

The well known treatises of Geber,¹⁰ "Of the Investigation of Perfection," "Of the Sum of Perfection," "Of the Invention of Verity," and "Of Furnaces," notwithstanding a bewildering style of composition, which seems to confirm Dr. Johnson's derivation of

gibberish, from Geber, display very great familiarity with a large number of chemical substances and operations.

Geber's works are generally assigned to the eighth century and consist chiefly of compilations from the "Books of the Ancients;" he mentions no author by name. They contain chapters devoted to the seven known metals, to the methods of distillation, calcination, cupellation and other operations, to the preparation of saline substances and to chemical philosophy. Geber adopted Aristotle's views of the constitution of matter from four principles, the hot and cold, the wet and the dry, and adds thereto: "Mercury and sulphur are the components of metals," a doctrine which with slight modifications prevailed for more than eight centuries. Geber describes the preparation of nitric acid, of aqua regia, and of mercuric oxide; he mentions the increase in weight of metals when calcined with sulphur, and gives the results of a rude quantitative analysis of crude sulphur. He constantly maintains the doctrine of transmutation of metals and gives a refutation of the ingenious arguments opposed thereto. His remarks on the qualifications of a chemist are most intelligent and are not inopportune in modern times; he urges the necessity of diligence, patience, learning, a temperate disposition, slowness to anger, and a full purse, "for this science agrees not well with a man poor and indigent," together with faith in the God who "withholds or gives to whom he will" the secrets of nature, and who will infallibly punish the foolish meddler with magical mysteries.

To detail fully our obligations to Arabian chemists is no part of our plan. They have left an indelible impression on the very language of the science, in the words alcohol, alembic, alkali, borax, and many others. All honor to the intelligent authors who a thousand years ago defined chemistry as the "Science of Combustion, the Science of Weight, the Science of the Balance!"¹¹

In the middle ages intellectual activity was confined largely to the clergy, who controlled the schools of learning, the libraries, and nearly all sources of knowledge. University chairs were occupied exclusively by clerical professors¹², literature and science were cast in ecclesiastical moulds. Scientific treatises were the production of monks and emanated from cloisters. Many distinguished philosophers mastered widely separated branches of learning: among these were Alain de Lille (b. 1114), celebrated as a

physician, theologian, poet and historian, who filled the episcopal chair at Auxerre; Roger Bacon (b. 1214) an English cordelier; Raymond Lully (b. 1235), a Franciscan friar, and Albertus Magnus (b. 1193), Bishop of Ratisbon. The latter, amid the monotonous routine of a Dominican monastery, found leisure to distinguish himself in astronomy, medicine, alchemy and, according to his enemies, in necromancy. At this remote period, accusations of dealing with magic were not unfrequently made against those whose learning and skill in experimental sciences excited envy and superstitious zeal.¹³

To treat the writings of these eminent ecclesiastics as a part of chemical literature requires perhaps a stretch of the imagination, yet three hundred years ago they were regarded as masterpieces of the science and formed the text-books of students of alchemy. The writings of these ecclesiastical philosophers are as comprehensive as the branches of learning they cultivated, and incredibly voluminous; Albertus Magnus' collected works fill twenty-one folio volumes.¹⁴ But a small fraction of these treatises are occupied with science and chemistry; and of this fraction there is in many cases a reasonable doubt as to their authenticity. In fact, nothing was more common than the ascription of work by an obscure second-rate writer to some celebrated philosopher of preceding ages, in order to give the work the stamp of authority,—a deception which previous to the invention of printing was more readily accomplished.

It became difficult therefore to distinguish the apocryphal writings from the genuine. The former, it is true, frequently betray themselves by anachronisms and other blunders, but many ingenious writers avoided such traps by adopting an enigmatical style worthy of the Delphian oracles.

Basil Valentine was the reputed author of works held in the very highest esteem by the alchemists of the Middle Ages, yet the very existence of this individual is seriously questioned. Mystery surrounds Valentine's entire history, and his writings were given to the world in a most dramatic manner; according to tradition they were hidden in the wall of a church at Erfurt and long after his death a thunderbolt shattered the wall and revealed the precious documents.

Whether Valentine was a real personage or not the works ascribed to him exhibit great familiarity with many chemical sub-

stances and operations, though the obscure and incoherent style renders their intelligent perusal very difficult.

Valentine's celebrated "Chariot of Antimony,"¹⁵ extolling the medical virtues of this metal, is perhaps the least obscure of his works; the "Twelve Keys of Philosophy"¹⁶ with its singular plates, one of the most unintelligible; yet beneath the extravagant jargon characteristic of the period, glimpses are obtained of light and intelligence. The latter work presents clearly the theory that all metals are compounded of three principles: fixedness, metallicity and volatility, represented respectively by salt, mercury and sulphur, an hypothesis which long completely controlled chemistry until it gave place to the seductive theory of Phlogiston. It is uncertain whether the works ascribed to Valentine were first written in Latin or in German; his writings were collected in the seventeenth century and have been through many editions.¹⁷ Several of his treatises have been translated into English and into French.¹⁸

In the fifteenth century the newly invented printing press was employed in the production of few works which can be regarded as chemical, and these were chiefly confined to isolated treatises of the ancient philosophers; in the sixteenth century the alchemists began to publish the results of their industry and speculations, and in the succeeding century a prodigious number of alchemical works were issued in Germany, France and England, creating literature of an extraordinary type.

Some of these treatises, which are numbered by thousands, record valuable experiments made by enthusiasts seeking the philosopher's stone, but the majority contain "a crude mass of incoherent propositions and wild assertions, a mixture of poesy and insanity, in which all logical ideas are lost amidst the stilted phraseology, but through which breathed a blind yet fervent faith."¹⁹ Great obscurity of style²⁰; an enigmatical method of naming chemical substances which found its highest development in the use of arbitrary symbols and the pictorial representations of alchemical processes²¹; the intimate association with astrology; the honest or affected intermingling of pious comments and prayers²²; the extravagant claims to antiquity as respects authorship and processes²³; the attempts to interpret the mythology of Egypt and Greece on an alchemical basis; the endeavor to associate the mysteries of Hermes with the sacred truths of the Christian religion²⁴,—all combine to produce literary monstrosities as fascinating to the student of chem-

ical history as they are profitless to the practical worker in modern science.

Among the fabulous writings, highly esteemed by the credulous alchemists, may be mentioned the celebrated inscription of Hermes Trismegistus upon an Emerald Tablet²⁵, the Golden Leaves of Abraham, Jew Prince, Priest, Levite, Astrologer and Philosopher, which in the hands of Nicolas Flamel²⁶ yielded such a rich harvest, the Practical Chemistry of Miriam the sister of Moses²⁷, and a multitude of grotesque writings ascribed to personages of known reputation. Raymond Lully is credited with five hundred works; Hermes Trismegistus, the mythical Father of Sciences, with several thousand.

Many of the alchemical works published during the period of which we speak are degraded by admixture of the contemporaneous pseudo-sciences, judicial astrology and magic. To this class belong the celebrated works of Dr. Fludd and the writings of the Rosicrucians; excluding these as wholly beneath our consideration the number of occult works on alchemy is still very large. We imagine it will be hard to discover in the whole range of literature writings having scientific pretensions more senseless than the aphorisms of the disciples of Pythagoras, collected in the "*Turba Philosophorum*"²⁸ so often quoted by the alchemists of the sixteenth and seventeenth centuries. Its improbable character is perhaps equalled by the "*Gloria Mundi*" in which the anonymous author favors his readers with the chemical views of Aristotle, Plato, Socrates and Democritus, interspersed with equally authentic statements by Hermes and Morien, Lamech and Methuselah, Abel and Seth, and even of Adam himself.²⁹

In the early part of the seventeenth century, Michael Maier, physician to the Emperor of Germany, Rudolph II, a royal patron of astrologers and alchemists, published several treatises now much sought after by alchemical bibliophiles.³⁰ Maier's "*Symbola aurea mensæ*" and "*Atalanta Fugiens*" contain emblematic plates, supposed to illustrate the hermetic interpretation of the fables and allegories of Egypt and Greece.

The connection between these ancient mythologies and the secrets of the philosopher's stone was a favorite subject with many authors and has been exhaustively treated by the Abbé Pernety in his two curious works "*Fables Egyptiennes et Grecques dévoilées*" and "*Dictionnaire Mytho-hermétique*."³¹ Not content with prose, several authors clothed their alchemical inspirations in poetry;

of these may be mentioned the Arabian treatises already named, the Twelve Gates of Alchemy by Sir George Ripley, written about 1450³², the Crede Mihi of Thomas Norton, written about 1477³³ and the Chrysopœia of Aurelius Augurelli.³⁴ The latter written in Latin hexameters with more pretensions to elegance than usual with the prosaic alchemists was dedicated in 1514 to Pope Leo X. Leo rewarded Augurelli by presenting him with an empty wallet, remarking that one who knew so well how to make gold had need only of a purse.

The alchemists, in common with their contemporaries in other branches of literature, took pleasure in prefixing to their essays eccentric titles; Helvetius writes of "The Brief of the Golden Calf (The World's Idol) discovering the rarest Miracle in Nature;"³⁵ Glauber names one of his treatises, "The Golden Ass well managed and Midas restored to reason."³⁶

Perhaps the height of absurdity is reached in the famous *Liber Mutus*³⁷, which consists of a series of fifteen symbolical engravings purporting to disclose the whole Hermetic Philosophy. The utterly unintelligible character of much alchemical literature is occasionally acknowledged by those who otherwise accepted the prevailing popular belief in transmutation; Lenglet du Fresnoy, speaking of Raymond Lully's Clavicula, says "Lully assures us that this treatise is indispensable to the comprehension of his writings; but, after reading it, one is little wiser than before."³⁸

There are several large collections of alchemical treatises which the curious in these matters should consult; the most extensive is Zetzner's *Theatrum Chemicum*³⁹ published in 1613 in six octavo volumes; this contains no less than 209 distinct treatises, notwithstanding which Lenglet du Fresnoy remarks that many excellent ones are wanting. Manget's *Bibliotheca Chemica Curiosa*,⁴⁰ published in 1702 in two folio volumes, contains 133 treatises; and the *Musæum Hermeticum*⁴¹ (1678) contains 21 treatises, some of which are illustrated. The most extensive English collection is Ashmole's *Theatrum Chemicum Britannicum*, published in 1652, and a noted French collection is Salmon's *Bibliothèque des Philosophes Chimiques* (1672), of which the edition by Richebourg (1741) is by far the best.⁴²

Stimulated by avaricious hopes, the zealous alchemists labored most industriously; and, by subjecting mixtures of all known substances to heat and to the action of acids, discovered a multitude of new bodies having more or less medical and economic value.

As we have seen, their writings consist for the most part of monographs describing disconnected experiments, with no attempt at exhaustive treatment of any single topic, no classification of phenomena and no well studied arrangement of material such as characterizes later handbooks. Nor can a scientific collocation be expected during the formative period of chemistry and previous to the introduction of theories around which to group the isolated phenomena. One of the earliest attempts to treat chemical facts in a systematic manner was made by Sir George Ripley, Canon of Bridlington, who lived in the fifteenth century. In his "Compound of Alchemy" written in 1471 the whole science of hermetic chemistry is unfolded in a poem divided into twelve sections called "Gates" through which the reader is conducted to the mysteries of transmutation.⁴³

"But into chapters thys Treatis I shall devyde,
In numbre twelve, with dew recapitulatyon;
Superfluous rehearsalls I lay asyde,
Intending only to give trew informatyon
Both of the theoryke and practical operatyon:
That by my wrytyng who so wyll guyded be,
Of hys intente perfectly speed shall be.

The fyrst chapter shall be of natural Calcination;
The second of Dyssolution, secret and phylosophycall
The thirde of our elementall Separation;
The fourth of Conjunction matrimonial;
The fyfth of Putrefaction then followe shall;
Of Congelation Albyficative shall be the sixt,
Then of Cybation, the seaventh shall follow next.

The secret of our Sublymation the eyght shall show;
The nyynth shall be of Fermentatyon;
The tenth of our Exaltation I trow.
The elevent of our mervelose Multipliyatyon,
The twelfth of Projection; then Recapitulatyon,
And so this treatise shall take an end,
By the help of God, as I intend.

.
Thus here the Tract of Alchemie doth end;
Which tract was by George Ripley, Chanon, penn'd.
It was composed, writt and signed his owne,
In anno twice seaven hundred seaventy one.
Reader, asslst him, make it thy desire,
That after life he may have gentle fire! Amen.

Ripley's versification and theme remind one of Chaucer's Canon's Yeoman's Tale composed nearly one hundred years earlier.

We can only briefly allude to Paracelsus' bombastic productions⁴⁴, which are concerned chiefly with medical chemistry, and to the remarkable works of George Agricola⁴⁵, distinguished by profuse illustration, portraying the apparatus and operations of mining and metallurgy in the sixteenth century.

Conspicuous for accuracy of description and systematic arrangement of topics is the "Alchymia" of Andrew Libavius, published at Frankfurt in 1595.⁴⁶ Libavius, a physician and teacher in the gymnasium at Coburg, rejected the absurd doctrines of the adherents of Paracelsus, combated superstition and quackery and, excelling in observation of chemical phenomena, gained a worthy position among his compeers. In his *Alchymia* he treats of the *Encheria* or manual operations of chemistry and of the *Chymia* or descriptions of substances, in separate books. The former he divides into two sections, one dealing with the instruments and the other with the management of fires and construction of furnaces. He describes at length a sumptuous laboratory provided not only with every requisite for chemical experimentation, but also with means of entertaining visiting guests, including such luxuries as baths, enclosed corridors for exercise in inclement weather, and a well stocked wine-cellar.

Libavius was the discoverer of stannic chloride which still bears the name "fuming liquor of Libavius"; he describes the method of preparing artificial gems by coloring glass with divers metallic oxides, and he seems to have been the first to apply the balance to the examination of mineral waters. Notwithstanding his progressive position he devotes eighty pages of his Commentary to the Philosopher's Stone in which he was a firm believer. The second edition of his works, published in 1606, forms a folio of 800 pages. It has sometimes been called the First Text-book of Chemistry.

The "Tyrocinium Chymicum" (1608) of Jean Beguin⁴⁷, Almoner to King Louis XIII of France, a less pretentious work, is characterized by freedom from ambiguity and prolixity as well as from hermetic superstitions; it deals chiefly with the medical applications of chemistry.

In 1660, Nicolas le Febvre, demonstrator of chemistry at the Jardin des Plantes, published a "Traicté de la Chymie"⁴⁸ greatly superior to all preceding works of its kind. He collected the most reliable theories and experiments from all published sources

and arranged them in a logical, systematic manner. The first six chapters treat of the theory of chemistry; the author admits five elementary principles: phlegm (or water), spirit (or mercury), sulphur, salt and earth, the first three being ingredients of volatile substances, and the latter those of refractory bodies. He defines metals as hard bodies generated in the bowels of the earth, capable of extension under the hammer and of being melted by fire. He divides metals into the perfect and the imperfect, and also into male and female, the latter subdivision being based upon their behavior with acids; gold, lead and antimony are male metals because soluble only in aqua regia, and the other five, silver, copper, iron, tin and mercury are female, because soluble in unmixed acids.

In the second part the author discusses the manipulations of chemistry and recognizes many nice distinctions now overlooked; for example, under the head of mechanical division he describes in detail the following operations: "limation, rasion, pulverization, alcoholization, incision, granulation, lamination, putrefaction, fermentation, maceration, fumigation both dry and humid, cohobation, precipitation, amalgamation, distillation, rectification, sublimation, calcination both actual and potential, vitrification, projection, lapidification, extinction, fusion, liquation, cementation, stratification, reverberation, fulmination or detonation, extraction, expression, incineration, exhalation, digestion, evaporation, desiccation, circulation, congelation, crystallization, fixation, volatilization, spiritualization, corporification, mortification and revivification."

In the experimental part Le Febvre explains the arrangement in the following language:

"We shall begin with the meteoric bodies, rain, dew, honey, wax and manna; we shall then describe the preparations made from animals and their secretions; next, the numerous products of the vegetable world; and lastly, the mineral kingdom with its stones, salts, marcasites and metals;" a division still recognized.

The order in which he treats mineral chemistry is as follows: Earths; stones, precious and otherwise; metals; semi-metals, embracing mercury, antimony and bismuth; salts, including common salt, saltpetre, alum, sal-ammoniac and the vitriols; and lastly, the sulphuretted minerals, arsenic, etc. Under each division he gives precise instructions for numerous experiments upon these

substances and describes their medicinal value. The whole work is written in a clear style, free from affectation of mystery; it rapidly passed through five editions, and was translated into English and German.

Three years after the appearance of Le Febvre's *Traité*, his successor at the Jardin des Plantes, Christopher Glaser⁴⁹ of Basle, published a work having the same title also marked by special excellence.

The most successful handbook of the seventeenth century was undoubtedly the "Cours de Chymie" by Nicolas Lemery,⁵⁰ an eminent lecturer in Paris. The first edition of this work was published in 1675, and it reached the tenth edition before the close of the century; a fourteenth edition enlarged by Baron appearing as late as 1756. It was also translated into English (1677), German (1698), Italian (1763), and Spanish. The remarkable success of this work is due to a facility for describing dry facts with remarkable simplicity and accuracy. His style is more concise than Le Febvre's, and his arrangement of material shows a progressive spirit. The limits of this address forbid an analysis of Lemery's Handbook, which, moreover, is better known than some others to which we have granted fuller treatment.

Passing over a period of fifty years, the next complete compendium of chemical knowledge which we notice is the "Elementa Chimiæ" of Hermann Boerhaave, the celebrated professor of botany, chemistry and medicine in the University of Leyden. Boerhaave's great erudition, purity of style and brilliant eloquence attracted students in great numbers; such was the popularity of his lectures that "certain booksellers who aimed at lucre by the most scandalous means" published them in 1724, without his authority or consent; this "surreptitious edition"⁵¹ contained, as Boerhaave himself complains, such "false, ridiculous and absurd things in every page," that he was compelled to publish his lectures in an accurate and complete form. Both editions were translated into English by Dr. Peter Shaw, and the authorized work passed through many editions in Latin, French and German.⁵² Instead of attempting to give an analysis of two quarto volumes, we will quote Boerhaave's own account of his plan.

"My design," he says, "is to initiate students in the knowledge of chemistry; and to do this in the most effectual manner, I

shall give a clear methodical explication of all that is necessary for understanding the best authors and for performing the chief operations in this experimental art." After acknowledging the difficulty of a systematic treatment of "a science which has been cultivated rather by experiments at random than upon any regular principles, and by persons usually destitute of all . . . knowledge in the liberal arts;" he claims that "these obstacles may be surmounted by making a collection of the several effects, which the art has actually produced, justly deducing general rules therefrom and duly digesting the whole." He then explains the division of his work into three parts.

"The first will rehearse the origin, progress, cultivation and fortune of chemistry, . . ; the second part will deliver certain theorems or principles of chemistry; the third will exhibit the actual operations of chemistry, whereby bodies are changed agreeably to the rules of the art and to the end proposed therein." Boerhaave's sketch of the history of chemistry begins with the earliest times but seems to have been left incomplete; it is rendered useful by classified lists of chemical writings and numerous references.

In his treatment of the theory he departs somewhat from his plan and introduces material which really belongs to the third or practical part. Boerhaave introduces sections on the use of chemistry in natural philosophy, in medicine and in the mechanical arts; gives an exhaustive account of the wonderful nature of fire and experiments in heat, together with ingenious speculations concerning the heat of celestial bodies; he describes the various forms of chemical apparatus and the preparation of curious and useful substances from the vegetable, animal and mineral kingdoms. Boerhaave exhibited the spirit of a true philosopher and produced a work of extraordinary merit. He was quite free from the follies of alchemy, though he cautiously remarks that "we should always remember the limits of nature are by no means to be defined by us, things are taken for impossible which are only unknown by the ignorant" and "many things in chemistry are apparently more incredible than that lead should lose its natural form and be converted into gold."⁵³

Contemporary with the systematic compilations of Libavius, Le Febvre, Boerhaave and others, were published hosts of independent works setting forth the results of prodigious labor in the chemical laboratory; many of these are filled with descriptions of

experiments made at haphazard, with no definite object in view, and having no necessary connection with each other.

Glauber's⁵⁴ voluminous writings, published in 1658, may be taken as an example of this class; in his works, amid controversies with Galenical physicians and curious apologies resulting therefrom, amid descriptions of alchemical mysteries and receipts for a universal panacea, amid extravagant praises of the "sal mirabile" (Glauber's salt), and curious narratives of personal history, we find many novel chemical facts having a medical or an industrial value. The whole is clothed in a very crude style with an affectation of secrecy and under capricious captions.

On the other hand, some of these treatises show signs of genius, especially in attempts to establish theories in explanation of the familiar yet astonishing phenomena; thus Van Helmont, whose contributions to medical chemistry we pass by, invented the word *gas* to aid in discriminating aeriform bodies⁵⁵; and Rey, in his "Essays on the increase in weight of tin and lead when calcined⁵⁶," demonstrated the weight of the air thirty years before the masterly researches of Boyle.

To attempt in this rapid review to do justice to the philosophical writings of the Hon. Robert Boyle is a hopeless undertaking. From his first publication, in 1660, "New experiments, physico-mechanical, touching the spring of the air and its effects," to his posthumous treatise "Medicinal Experiments," published in 1692, his works teem with ingenious experiments described with great candor and fidelity, and from which conclusions are drawn with cautious reserve and philosophical soundness, as admirable as his rare modesty.

In his "Sceptical Chymist" (London, 1661), Boyle raises doubts as to the elementary nature of earth, air, fire and water, as well as of the alchemical principles, sulphur, salt and mercury, and claims that the first elements of bodies are atoms of different shapes and sizes, the union of which forms what are vulgarly called elements; he argues that their number should not be confined to three nor four, but that probably a large number of primary constituents would eventually be separated or isolated as such. He also first clearly recognizes the distinction between mixture and chemical combination.

The rejection of Boyle's prophetic hypothesis by his contemporaries much retarded the progress of the science. "More, how-

ever, than for his views on the nature of the elements, science is indebted to Boyle for his clear statement of the value of scientific investigations for its own sake, altogether independent of any application for the purposes either of the alchemist or of the physician . . . Boyle was in fact the first true scientific chemist, and with him we may date the commencement of a new era for our science when the highest aim of chemical research was acknowledged to be the simple advancement of natural knowledge." (Roscoe.)

Boyle's voluminous writings were collected by Birch in five folio volumes and published in 1744. His diffuse style of composition, with frequent long digressions, renders a perusal of his writings wearisome and led to an edition by Dr. Shaw, in which his works are "abridged, methodized and disposed under general heads," forming three quarto volumes bearing the date 1725.⁵⁷ Many of Boyle's papers were published in the *Philosophical Transactions*.

The literature pertaining to the theory of phlogiston belongs almost wholly to the eighteenth century. It is true that Becher's *Physica Subterranea* was published in 1659⁵⁸, but the theory of a combustible principle existing in all metals remained dormant until Becher's admirer, George Ernest Stahl, published an edition of the *Physica Subterranea* in 1702; to this he prefixed a long preface elaborating those doctrines which exerted such immense influence on both the theoretical and practical science, for more than a century. The writings of Becher and Stahl are notorious for their barbarous mixture of poor Latin and German, for which indeed both authors apologize.⁵⁹

In Mayow's *Treatise on the nitro-aërial spirit*⁶⁰, we find records of admirable experiments in pneumatic chemistry supported by accurate reasoning and almost prophetic insight of later theories of combustion, but his early death prevented the continued support of his views, and Mayow's treatise was soon forgotten by the prejudiced followers of Stahl.

In the year 1683 a noteworthy event occurred in the chemical world, the opening of public laboratories of instruction. Chairs of chemistry had long existed in institutions of learning, the first being filled nearly eighty years before by Johann Hartmann, and the honor belonging to the University of Marburg. Practical in-

struction had been secured also in the private laboratories of the wealthy, thus Homberg and Friedrich Hoffmann worked in Boyle's establishment⁶¹; but the first public laboratory for instruction was opened at Altdorf, Bavaria, under the direction of Prof. J. M. Hoffmann. A survey of the status of chemical knowledge at that date offers a tempting digression but the length of this address forbids.

The second public laboratory was opened in the same year (1683) at Stockholm, under the patronage of Karl XI of Sweden, and under the guidance of Urban Hiärne. Both institutions issued publications bearing the general title *Acta*⁶² which may be regarded as forerunners of the "Contributions from the Laboratory of ——— University" now so common in periodical literature.

Lexicons and dictionaries have been a feature of chemical literature from the earliest times; we have already alluded to the vocabularies of the sacred art found among the Greek MSS. of the Paris National Library and referred to the tenth and eleventh centuries. These, however, seem to have been compiled for the purpose of misleading the novice in alchemical mysteries, and as Hoefer justly remarks themselves need commentaries to become intelligible.

The universal employment of symbolic characters, to represent both chemical substances and operations, rendered alchemical literature difficult of perusal and early led to the publication of keys and vocabularies explaining them. Such keys occur in the manuscripts just mentioned, in Eschenreuter's "Universal Panacea for Men and Metals"⁶³ which purports to have been written in or before the fourteenth century, and in the works of Oswald Crollius⁶⁴, Kircher⁶⁵, Le Febvre, Lemery and many authors of the seventeenth century: these however are not properly dictionaries.

Dr. Martin Ruland, court physician to Rudolph II, published a "Lexicon alchemiæ" in 1612, and William Johnson⁶⁶ a "Lexicon chymicum" in 1657, but the first really satisfactory treatment of chemistry in monographs alphabetically arranged was by Macquer⁶⁷ whose "Dictionnaire de Chymie," published in 1766, had great success, passing through several editions and being translated into the German, English, Italian, Spanish, Danish and Russian languages.⁶⁸ Macquer found many followers, among whom

may be mentioned Nicholson (1795), Cadet (1803), and well known authors whose works are indispensable to all students of the science.

Prof. Wm. Ripley Nichols, of Boston, late chairman of this Section, in a recent private communication, has expressed the need of yet another dictionary, one of chemical synonymes. He calls attention to the large number of names by which certain chemical substances have been known at different epochs and in different professions, and to the utility of a dictionary explaining their synonymy. Professor Nichols suggests "restricting the list to terms found in the literature of the preceding hundred years, but including such alchemical names as have peculiar historic interest and such as have persisted more or less in commerce and pharmacy." He also suggests that the work should include English, French and German names, except when they are simply literal renderings of the same term, and names of those minerals which are of simple composition like halite, witherite, fluorite, etc., under their appropriate heading. In an example of the proposed method of treatment he gives a long list of names for ferric oxide under the several heads: alchemical, chemical, mineralogical, pharmaceutical, commercial and popular.

The idea is certainly excellent and we have Professor Nichols' permission to mention it publicly in the hope that some one may be incited to compile such a work. We are not aware of the existence of any modern chemical synonymicon, not having seen Berta's Dictionary of chemical terms⁶⁹, published at Padua in 1842; perhaps the nearest approach to the ideal work of Professor Nichols is Sommerhoff's Lexicon pharmaceutico-chymicum⁷⁰, published in 1701, a folio of 400 pages.

About the middle of the seventeenth century the dissemination of the views of Lord Bacon, as expressed in his *Novum Organon*, gave a great impulse to scientific investigations, and the "splendid fiction of the new Atlantis" was practically realized in the foundation of the "Royal Society for improving Natural Knowledge." The learned men, who in 1645 met in London, and there disturbed by unhappy dissensions of civil war withdrew to Oxford to report and discuss philosophical experiments, laid the foundations of an edifice destined to rise higher, endure longer and to shelter a nobler offspring than the most sanguine could have foreseen. The organization was granted a charter by King Charles II in 1662 and

three years later began the publication of the "Philosophical Transactions, giving some account of the present undertakings, studies and labours of the ingenious in many considerable parts of the world." In the following year the French Academy of Sciences began their *Mémoires*. Thus arose the element of periodicity in scientific literature, one which rapidly increased in importance.

The year 1665 also witnessed the birth of the parent of that large class of periodicals not issued by societies but published by private parties either individually or coöperatively. The first number of the "*Journal des Scavans*" appeared January 5, 1665, and for one hundred and thirty years was the most prominent literary and scientific journal of Europe. At that early date the periodicals partook of a literary nature rather than of the scientific, but gradually these two elements became distinct and the lines became more and more closely drawn until every branch of pure and applied science supported a serial especially devoted to its progress. Among the earliest periodicals devoted to chemistry and its associate physics may be mentioned the "*Journal de Physique et de chimie*," edited by the Abbé Rozier, de la Méthérie and others, begun in 1770 and continued through ninety-five volumes to 1822; the "*Chemisches Journal*" of Lorenz Crell, 1778-86, which was followed by the "*Chemische Annalen*" by the same editor, extending until 1803. The "*Annales de Chimie et de Physique*," begun in 1789, enjoys the honor of being the oldest surviving serial of this class.⁷¹

Of the foundation of Societies exclusively devoted to chemistry in France, England, Germany and America, and of their periodical publications, we can make mere mention. The existence of a "Columbian Chemical Society" in Philadelphia, as early as 1811, deserves passing notice. Two volumes of its *Memoirs* were published containing articles by Drs. Mitchell, Cutbush, Mannors, Bache and others.

Of chemical bibliography and works relating exclusively to the history of the science, we have elsewhere⁷² given a critical résumé.

As we proceed with this review of chemical literature, the publications increase enormously in number, variety and importance, and the end of our undertaking seems to move forward faster than we progress. It is manifestly impossible in the brief time allotted to this address to analyze the chemical literature of the preceding hundred years. How shall we attempt to portray the

theories and experiments recorded in the writings of Bergmann⁷³, Scheele⁷⁴ and Galin, the eminent Swedes; of Black⁷⁵, Cavendish⁷⁶ and Priestley⁷⁷, the English triumvirate; of the French philosophers Fourcroy⁷⁸, de Morveau⁷⁹, and Lavoisier⁸⁰; of the industrious German chemists Kunckel⁸¹, Marggraf⁸², Wenzel⁸³, Klaproth⁸⁴ and Richter⁸⁵; or of the Italian philosophers Galvani⁸⁶, Volta⁸⁷, and Brugnatelli⁸⁸. And passing to a later period, how shall we do justice to the labors of Berthollet⁸⁹, Gay Lussac⁹⁰, Thénard⁹¹ and Laurent⁹²; of the immortal Dalton⁹³, of the brilliant Davy⁹⁴ of the indefatigable analyst Berzelius⁹⁵; of Mitscherlich, Liebig, Wöhler, and Hoffman; of Dumas, Berthelot and Adolph Wurtz; of Graham, Frankland, Abel and Crookes?

American contributions to chemical literature have been exhaustively discussed in the hearing of many present and need not now detain us; I refer to Prof. Silliman's Address at the celebration of the centenary of Priestley's discovery of Oxygen, held at Northumberland in 1874.⁹⁶

The modern period of chemical literature is characterized by two opposing forces, a tendency to dispersal and an effort to collect the widely scattered publications. The multiplication of learned societies especially in Europe, each of which supports its own organ, and the increasing number of nations interested in scientific pursuits, in each of which arises an independent periodical, tend to the wide dispersal of memoirs, essays and notices.

On the other hand, industrious editors laboriously collect and set in order these scattered observations, constructing compact, massive handbooks and many volumed cyclopedias. The monumental work of Gmelin, which is even now passing through another edition, has worthy rivals in the magnificent compilations edited by Henry Watts and by Adolph Wurtz, and in the work of Beilstein in a field of special difficulty. For systematic treatises we can point to Miller, Graham-Otto, Pelouze et Frémy, Roscoe and Schorlemmer and the ever youthful Fownes.

Invaluable, too, are the annals known as *Jahresberichte*, monuments of conscientious editorship.

Another feature of modern growth is the multiplication of special treatises dealing with single topics in every branch of chemistry, inorganic, organic, theoretical, analytical, technological, pharmaceutical and physiological, until mere acquaintance with their titles

becomes a serious undertaking for busy workers in the laboratory.

The amount of time and labor required to search for a given point throughout the maze of modern chemical journals, transactions, treatises and hand books, is well appreciated by my audience; the superb dictionaries and annals referred to accomplish much in cataloguing, condensing and systematizing the infinity of observations; nevertheless, all working chemists feel the need of special indexes, simply arranged, as complete as possible and accessible to every one. Sharing in this feeling, I have contributed my mite to the literature of chemical indexes and have inspired several friends, fellow-members of this Association, with the courage to follow. Uranium⁹⁷, Manganese⁹⁸, Titanium⁹⁹, Vanadium¹⁰⁰, Ozone¹⁰¹, and Peroxide of Hydrogen¹⁰² have been indexed on a uniform plan, and my pupil W. W. Webb, B. S., has prepared an Index to the Literature of Electrolysis¹⁰³, which will soon be published in the same channel as the others;— the *Annals of the N. Y. Academy of Sciences*.

Pardon, we beg you, these personal allusions: we have indulged in them with the object of bringing before this Section a proposition for organized effort in the preparation of Indexes to all the Elementary Substances on a uniform plan.

The advantages which would accrue from the publication of special indexes to the literature of the elements and of such other subjects as may prove desirable are too obvious to need argument; I have thought that the undertaking might be placed in the hands of a Committee of the Chemical Section of this Association. The existence of an Index Society in England under the guidance of Henry B. Wheatley, F. S. A., Hon. Sec.,¹⁰⁴ affords a precedent, if indeed any be required.

The first duty of the Index-Committee of the Section of Chemistry would be to secure volunteers willing to undertake the compilation of special indexes; surely in this National Association a few chemists can be found ready to coöperate in such an important work. The Committee would further adopt a uniform plan for the indexes, determine the method or channel of their publication, and exercise general editorial supervision over the undertaking.

Hoping that this suggestion will receive your approbation I leave it in your hands.

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104. Mr. Wheatley's address is 5 Minford Gardens, West Kensington Park, London W., England.

CENTENNIAL OF CHEMISTRY, 1774-1874.

To the Editors of the American Chemist :—

Dear Sirs: The year 1774 was rendered memorable by great chemical activity. It is not possible to assign to Chemistry any definite birth-year, but so many remarkable discoveries were made in 1774 that we may, with good reason, date the foundation of modern chemical science from that period.

It would be quite foreign to the object we have in view to give here any detailed account of the state of the science at the period referred to. We may mention, however, a few of the most important discoveries which made the year 1774 noted in the annals of Chemistry.

The eminent Swedish chemist, Scheele, first isolated chlorine, calling it, in accordance with the accepted theories of the day, "dephlogisticated muriatic acid." He also recognized baryta as a peculiar earth, and it henceforth took a place among the elementary substances. Scheele also published in this same year his masterly essay on Manganese.

Lavoisier was engaged in an investigation of the cause of the increase in weight of tin when calcined in close vessels—a research which led him to subsequent discoveries of immense importance.

Wiegand proved alkalies to be true natural constituents of plants. Cadet described an improved method of preparing sulphuric ether. Bergman showed the presence of carbonic acid in lead white. On the 27th of September in this year Comus reduced the "calces" of the six metals by means of the electric spark, before an astonished and delighted audience of savants. On the first of August, 1774, Priestley discovered oxygen, the immediate results of which were the overthrow of the phlogiston theory.



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AN ACCOUNT OF THE PROGRESS
IN
CHEMISTRY
IN
THE YEAR 1882.

BY
Prof. H.
PROF. H. CARRINGTON BOLTON.

FROM THE SMITHSONIAN REPORT FOR 1882.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1883.

AN ACCOUNT OF THE PROGRESS

IN

C H E M I S T R Y

IN

T H E Y E A R 1 8 8 2 .

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WASHINGTON:
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1883.

ERRORS AND CORRECTIONS.

Page 1, 13th line from bottom, *the heading should read* "PHYSICAL AND INORGANIC CHEMISTRY."

Page 3, lines 8 and 9, " $\text{H}_2\text{O}_4\text{Mn}_2$ " *should be in one line.*

Page 6, line 19 (middle column of table), *for* "Gersdorffita" *read* "Gersdorffite."

Page 10, line 2, *for* "apotssium" *read* "potassium."

Page 10, 13th line from bottom, *for* "sluphuric" *read* "sulphuric."

Page 10, last line, *for* "Chm." *read* "Chim."

Page 12, line 4, *for* " Ca^3 , &c.," *read* " Ca_3 , &c."

Page 12, line 6, *for* " (2CaO_1) " " (2CaO) " [*i. e.*, dele $_1$].

Page 15, lines 5 and 6, " $\text{C}_{14}\text{H}_{14}\text{O}_4$ " *should be in one line.*

Page 16, line 24, *for* "Curtius" *read* "Curtius."

Page 18, line 15, *for* "dinethyl-" *read* "dimethyl-."

Page 22, line 5, *for* "sylphides" *read* "sulphides."

Page 22, line 17, *for* " Co_2 " *read* " CO_2 ."

Page 22, 17th line from bottom, *for* "hydrogen" *read* "hydrazin."

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CHEMISTRY.

By H. CARRINGTON BOLTON, Ph. D.,
Professor of Chemistry in Trinity College, Hartford, Conn.

The year 1882 is marked by great industry in all departments of chemistry; no startling announcements have been made, but several extremely interesting syntheses of organic bodies have been accomplished, viz, tyrosine and uric acid, both of the animal organism. Great activity is noted in the revision of the atomic weights. Progress has been made in unraveling the knotty problem of the rare earths in cerite, samarskite, and gadolinite, but no satisfactory conclusions have been reached as to the existence of the larger number of elementary bodies announced since 1877.

In the brief space at our disposal we can barely note the salient features of the year's work in a series of short abstracts, and these we confine chiefly to pure chemistry, paying little attention to analytical and industrial chemistry. Periodical literature, devoted exclusively to chemistry and its applications, is becoming voluminous; the fifteen principal journals of America, England, France, and Germany publish annually about 18,000 pages; in this rough estimate journals of physics and transactions of societies are not included, and both classes of serials contain much chemical material. We need hardly say that no attempt is made in the following pages to chronicle the prodigious amount and variety of work contained in these and other sources of information.

INORGANIC CHEMISTRY.

On the Reciprocal Solutions of Liquids.—Wladimir Alexejff has devoted eight years to a study of the mutual solutions of mixed liquids, and he finds that the hypothesis proposed by Dossios is subject to exceptions. The latter stated that the mutual solubility of liquids increases with the rise in temperature, but Alexejff finds that in certain bodies (isobutyl alcohol, for example) the solubility diminishes with an increase of temperature. He also discovers that the solubility decreases to a definite point and then increases again, or, in other words, that a *minimum* of solubility exists, just as certain solids have a maximum of solubility.

When phenol and water are brought together two layers form; the lower is a solution of phenol in water, the upper a solution of water in

phenol. Now the mutual solubility of these liquids increases with the temperature, and at a certain point (68° for *pure* phenol) the two liquids mix in all proportions. Many liquids, such as aniline and water, follow the same law; solids, too, obey the same law, as is shown by the mutual action of water and salicylic acid. The author claims that the solutions of solid and of liquid salicylic acid exhibit a true physical isomerism. (*Bull. Soc. Chim.*, XXXVIII, p. 145.)

Molecular Structure and Physical Properties.—That a close connection exists between the structure of molecules and the physical properties of the substances composed of these molecules is becoming more and more evident. Pawlewski finds that the "critical temperatures" of isomeric ethers are very nearly identical, and that isomers containing doubly-linked atoms of carbon have a higher critical temperature than those in the molecules of which the carbon atoms are singly linked. (*Berichte d. chem. Ges.*, XV, p. 460.)

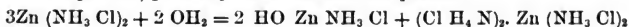
Determination of Gas Densities.—H. Goldschmidt and Victor Meyer have devised a simple method for determining gas densities in an expeditious manner. The process was employed at first in connection with experiments made on the density of cyanogen at various temperatures, but is applicable to many bodies. The vessel employed is first filled with pure, dry air of the temperature at which the density is to be taken; the air is then displaced by hydrochloric acid gas (free from air), collected over water and measured. The hydrochloric acid gas is in turn replaced by air. The gas to be examined is then introduced until all the air is expelled, and this gas is again displaced by hydrogen, or by air, and collected in a potash bulb containing a liquid capable of completely absorbing it. The increase in weight of the potash bulb gives the weight of the gas; the weight of an equal volume of air at the same temperature is determined from the volume collected, and the quotient gives the density sought.

The apparatus consists of a glass cylinder 200^{mm} long, 30^{mm} in diameter, with a capillary tube at each end, the extremities of which tubes rise above the upper end of the cylinder and are bent at right angles. This apparatus is heated in a glass tube with a bulbous extremity 400^{mm} long, and of sufficient size to contain the liquid, whose boiling point is the temperature of measurement. The liquids used in the outer vessel are water, aniline, amyl benzoate, and diphenylamine. For higher temperatures boiling sulphur and penta-sulphide of phosphorus are used, in which case the inner vessel receives a spherical form, and the outer vessel is made of iron.

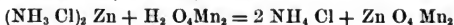
The authors obtained by this process a density of 1.53 for carbonic anhydride, and of 1.26 for hydrochloric acid gas, figures exactly equal to the theoretical values.

The apparatus can also be employed as an air thermometer. Sulphur was found to boil at 426° C. (*Berichte d. chem. Ges.*, XV, p. 137.)

Chemical Reactions in the Leclanché Cell.—Dr. Edward Divers has presented the following reactions: Zinc is slowly acted upon by a solution of ammonium chloride, and crystals of zinc-diammonium-chloride are formed; this is decomposed by water alone into an insoluble and a soluble portion, probably as shown in this equation:

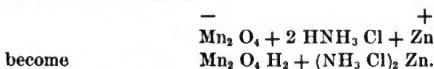


Zinc-diammonium-chloride dissolved in solution of ammonium chloride acts gradually on artificially prepared hydrogen manganite, $\text{H}_2\text{O}_4\text{Mn}_2$, causing manganese to go into solution, and the precipitation of zinc on the manganite, probably thus:

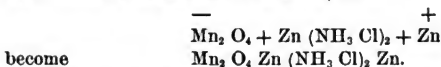


These experimental facts lead the author to the following theory of the action of the cell:

Primary action:—Formation of hydrogen manganite and zinc-diammonium-chloride:

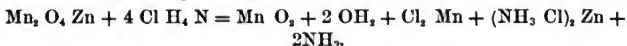


Secondary actions, causing polarization.—The hydrogen manganite acts locally upon the zinc-diammonium-chloride solution, and forms zinc manganite and ammonium chloride; this proceeds more rapidly by galvanic action when the cell is at work, thus:



The zinc manganite and the hydrogen manganite by coating over the manganese dioxide, protect it from the primary action of the ammonium chloride and zinc, and thus cause polarization of the cell.

Secondary actions, causing depolarization.—The ammonium chloride dissolves manganous and zinc oxides out of the manganite, the manganous oxide liberating ammonia:



The manganous chloride dissolves in the presence of the free ammonia as a double chloride of manganese and ammonium. By the solution of these oxides the manganese dioxide of the manganite becomes active again. The depolarizing action proceeds slower than the polarizing, and therefore the battery requires to be left uncircuited, in order to recover its full power after use. (*Chem. News*, XLVI, p. 259.)

Atomic Weights of the Elements.

Carbon.—Roscoe has redetermined the atomic weight of carbon by the direct combustion of the diamond. If $\text{O} = 15.96$, he obtained as a

mean of six experiments $C = 11.9757$. Dumas and Stas in 1840 obtained 11.9708. (*Comptes Rendus*, CIV, p. 1180.)

Uranium.—Zimmermann has prepared metallic uranium by Pélégot's method and studied its properties. Its specific gravity is 18.685, and its specific heat between 99° and 0° is .02765; the latter number multiplied by 240 gives a product of 6.64, which agrees with the mean atomic heat indicated by Dulong and Petit's law. This settles the controversy concerning the correct value in favor of 240 and in accordance with Mendeleeff's classification. (*Berichte d. chem. Ges.*, XV, p. 847.)

Glucinum.—Dr. James Blake thinks that the evidence derived from the physiological action of the salts of glucinum may be of use in determining its true position among the elements. He finds that the effects produced by the introduction into the blood of salts of Be are the same as those caused by the salts of alumina and of ferric oxide. He regards glucinum as a member of the aluminium group of metals. (*Chem. News*, XLV, p. 111.)

Aluminium.—The atomic weight of this element has been subjected to a painstaking revision by Prof. J. W. Mallet. The general mean of 30 experiments gives $Al = 27.032$, with a probable error of ± 0.0045 . [Oxygen = 15.961.] (*Chem. News*, XLV, pp. 256 et seq.)

Rubidium.—Charles T. Heycock has redetermined the atomic weight of rubidium with the view of testing its relation to Prout's hypothesis. The figures obtained by titration of the chlorine in pure chloride of rubidium are 85.344; and those by titration of the bromide are 85.387, results which lead the author to the conclusion that at present rubidium cannot be regarded as conforming to Prout's hypothesis. (*Report of British Assoc.*, in *Nature*, XXVI, p. 467.)

Didymium.—Brauner has determined the atomic weight of didymium as 146.18, and that of lanthanum as 138.88. (*J. Chem. Soc.*, XLI, p. 68.)

Yttrium has been prepared by Cleve free from terbium and its atomic weight redetermined. He assigns the value 88.9 to Y''' when $O = 15.9633$. (*Comptes Rendus*, December 11, 1882.)

Thorium.—L. F. Nilson has redetermined the atomic weight of thorium by ignition of the carefully purified sulphate: $Th (SO_4)_2 \cdot 9 H_2O$, and obtains as a mean of ten experiments 232.40. (*Berichte d. chem. Ges.*, XV, p. 2519.)

A recalculation of the atomic weights, by Prof. E. W. Clarke.—Brief mention must be made in this connection of the systematic recalculation of the atomic weights carried out by Professor Clarke and published by the Smithsonian Institution as Part V, of the Constants of Nature. Chemists are under great obligations for this invaluable treatise.

Composition of the Atmosphere.

Several chemists have carried on independently more or less elaborate researches on this subject. Reiset has made numerous determinations of the amount of carbonic anhydride in the atmosphere, and finds the

values usually given (4 to 6 volumes in 10,000) much too high. He gives 2,962 vols. in 10,000 as the mean of 220 experiments made near Dieppe. The ratios obtained in Paris are somewhat higher, being 3,168 vols. of carbonic anhydride in 10,000 of air. (*Ann. Chim. et Phys.* (5) XXVI, pp. 245 *et seq.*)

A. Muntz and E. Aubin have also made determinations of the proportions of carbonic anhydride in the atmosphere at Paris and near Vincennes, and the results (which confirm Reiset's figures) show that the variations in the amount of carbonic anhydride are due to local influences, and that in general the heavier gas is quite uniformly distributed throughout the lower strata of the atmosphere. These chemists also examined the air of elevated regions, conducting experiments at the altitude of 2,877 meters (9,422 feet) in the Pyrenees. Although the direction of the wind and state of the atmosphere varied greatly during their experiments, the proportion of carbonic anhydride was found to be constant, being about 2.86 vols. in 10,000 of air. For the sake of comparison the air was examined in two valleys at the foot of the Pyrenees, one near Pierrefitte (507 meters above the sea-level) and the other near Luz (730 meters); at the first station the air was found to contain 2.79 vols. of carbonic anhydride in 10,000, and at the second 2.69 in 10,000, the latter determination being made in the midst of luxurious vegetation. Muntz and Aubin conclude that carbonic anhydride is very uniformly distributed throughout the atmosphere, and regard their results as confirming Reiset's statements and Schloesing's theories concerning the circulation of carbonic anhydride upon the surface of the earth. (*Comptes Rendus*, XCIII, p. 797.)

Dr. Edward W. Morley has devised a method for accurate and rapid analyses of air, and has made a series of daily analyses in duplicate of air collected at Hudson, Ohio, for six months, beginning with January 1, 1880, and one for six months and twenty days, beginning October 1, 1880. For details of the apparatus and process we refer to the original paper. Each pair of analyses occupied about 70 minutes of time, and the mean error of a single analysis for half a month was less than the thousandth part of one per cent. By comparing the results of this long series of daily determinations with the data obtained from the thrice-daily maps of the state of the weather furnished by the United States Signal Service Bureau, Dr. Morley finds that most of the variations in the amount of oxygen are caused by the vertical descent of air from high elevations. This descent of cold air seems to be the effect of sudden and severe depressions of temperature rather than the cause; the descent follows the cold by a day or two, and the decrease in amount of oxygen begins simultaneously with the descent from above. (*Proc. Am. Assoc. Adv. Sci.*, 1881; abstract in *Chem. News*, XL, pp. 245, 284 *et seq.*)

List of New Elements announced since 1877.

The six years ending in 1882 have been unusually prolific in new elements, or at least in announcements of the same, for it must be conceded that most of them will fail to stand the test of more thorough investigation. These alleged discoveries are widely scattered in periodical literature, and the following list may prove useful for reference:

List of elementary substances announced from 1877 to 1882.

Date.	Name.	Source.	Discoverer.
1877	Neptunium	Columbite.....	Hermann.
	Lavcesium	Pyrite.....	Prat.
	Mosandrum	Samarskite.....	J. L. Smith.
	Davyum	Platinum ores.....	Sergius Kern.
1878	"New earths"	Unnamed mineral.....	Gerland.
	"X"	Gadolinite.....	Soret.
	Philippium	Samarskite.....	Delafontaine.
	Decipium.....	Samarskite.....	Delafontaine.
	Ytterbium.....	Gadolinite.....	Marignac.
1879	Scandium.....	Gadolinite.....	Nilson.
	Norwegium.....	Gersdorffite.....	Dahll.
	Uralium.....	Platinum.....	Guyard.
	Samarium.....	Samarskite.....	Lecoq de Boisbaudran.
	Barcenium.....	(Misapprehension).....	Wagner's Jahresbericht.
	Thulium.....	Gadolinite.....	Cleve.
	Holmium.....	Gadolinite.....	Cleve.
	Columbium.....	Samarskite.....	J. L. Smith.
	Rogorium.....	Samarskite.....	J. L. Smith.
	Yeshium.....	Lava.....	Seacchi.
1880	Comesium.....	.....	Kaemmerer.
	Ya and Y β	Gadolinite.....	Marignac.
1881	Actinium.....	Zinc ores.....	Phipson.
1882	Didymium β	Gadolinite.....	Cleve.

New Elementary Substances.—At the meeting of the Russian Chemical Society held October 20, 1881 (and reported in the *Bulletin de la Société Chimique de Paris*, for August, 1882), Mendeleeff, the distinguished author of the periodic law, remarked that only two of the recently announced elements—scandium and ytterbium—had been satisfactorily confirmed. These have been obtained in a pure state by Nilson, and neither of them has absorption spectra. All the other metals seem to be mixtures, as was the case with the old erbium of Bunsen and Bahr, and which proves to contain Sc, Yb, Er, Tr, and other elements. Scandium corresponds in its atomic weight and properties to *ekabor*, a hypothetical substance, the existence of which had been foreseen by the speaker.

Mendeleeff expressed himself convinced that his periodic law will find further confirmation in the results to be yet obtained in studying the elements of cerite and of gadolinite. (*Bull. Soc. Chim.*, XXXVIII, p. 140.)

A new element accompanying didymium is announced by the Swedish chemist, Prof. P. T. Cleve. He has long studied the rare earths existing in cerite, gadolinite, and similar minerals, and the behavior of the oxide of didymium obtained from the latter has led him to suspect the presence of a new element. In the beginning of the year 1882 he submitted to fractional precipitations about 200 grams of didymium oxide, and separated from the yttria earths with potassium sulphate by repeated precipitations; the atomic weight of the first fraction was 146, that of the

last 142. The examination of the ignition spectrum of the last fraction showed, besides strong rays of didymium and lanthanum, new rays, among which is a very strong one having the wave-length of 4333.5. This ray belongs neither to didymium, lanthanum, yttrium, erbium, terbium, nor to Marignac's Y_a , and is regarded by Cleve as peculiar to a new element which he designates provisionally by $Di\beta$. (*Comptes Rendus*; abstract in *Chem. News*, XLV, p. 273.)

Soon after the publication of the above statement by Professor Cleve, B. Brauner printed a note in the *Chemical News* (46, 16), in which he shows that he anticipated the Swedish chemist in discovering a new element accompanying didymium in cerite. His experiments were made in Professor Roscoe's laboratory, and some of his results were published in the *Anzeiger der kais. Academie der Wissenschaften* (October 6, 1881). Brauner thinks that oxide of didymium, as usually known to chemists, consists of a mixture of at least three elements, true didymium having an atomic weight = 145.4, Cleve's element, more basic than didymium, and a third with a higher atomic weight is less basic than didymium. This last may possibly be samarium.

Professor Cleve in a still later communication states that continued researches by himself and Thalèn have convinced him that the ray 4333.5 belongs to the spectrum of lanthanum, and that the existence of a new element is very improbable. (*Chem. News*, XLVI, p. 43.)

The earths contained in samarskite have been studied by Professor H. E. Roscoe, with the object of ascertaining the existence or non-existence of Delafontaine's philippium. Roscoe worked up 1,500 grams of samarskite and obtained about 60 grams of oxides containing terbium, erbium, yttrium, and philippium (?). The oxides were converted into formiates, and these salts carefully examined to obtain pure philippium salt, but the author failed to get an oxide having a constant atomic weight equal to 122 (claimed by Delafontaine). The numbers varied between the atomic weights of terbia and yttria. Roscoe then tried the following conclusive experiment: 3 grams of terbia, having an atomic weight of 147.9, and 3 grams of crude yttria, with an atomic weight of 101.4, were respectively converted into formiates. Of each of these two formiates, two thirds were brought into solution separately while the other third of the terbium formiate was mixed with the remaining third of yttrium formiate, and the mixture dissolved. Each of the three solutions was then mixed with an equal bulk of alcohol and allowed to stand for the same length of time. The two solutions, containing respectively terbia and yttria, gave crystals presenting the ordinary appearance of formiates of the metals in question, but the third solution containing the mixed formiates deposited rhombic prisms exactly like the crystals which Delafontaine claims are peculiar to the formiate of philippium. The non-existence of philippium is thus undoubtedly established. (*Chem. News*, XLV, p. 184.)

Researches on other Elements, etc.

Thorium.—Two important memoirs have been published by L. F. Nilsson on thorite and its chief constituent, thorium. He worked upon two kilograms of the rare mineral and prepared a very pure thorium sulphate, from which he made a determination of the atomic weight of the element. (See paragraph on atomic weights.) He determined the specific gravity of thoria, finding the figures 10.2199. He also prepared the metal by the reduction of potassio-thorium chloride with sodium in the iron apparatus he had previously used for beryllium. The metal obtained formed a gray shining powder showing distinct crystals under the microscope; it is unaltered by exposure to air up to 100–120° C.; when heated higher it burns brilliantly, forming a snow-white oxide. The metal burns in chlorine, bromine, and iodine gases, yielding sublimates; it is slowly attacked by dilute sulphuric acid, and by dilute nitric; concentrated nitric acid has very little effect. Hydrochloric acid dissolves the metal readily. The metal has the specific gravity of about 11, results being not perfectly satisfactory. (*Berichte d. chem. Ges.*, xv, pp. 2519–2547.)

Properties of Pure Metallic Aluminium.—Prof. J. W. Mallet, in the course of his researches on the atomic weight of this metal, required a quantity in a very pure condition, and this gave an opportunity of studying its properties. Crude (commercial) aluminium contains:

Al	96.89
Fe.	1.84
Cu.	trace.
Si	1.27
	100.00

This was converted into bromide by treatment with liquid bromine, and the product purified by fractional distillation. It was then reduced by sodium in a crucible lined with a mixture of purified and dried alumina, with sodium aluminate. The metallic globules were again fused and further purified with hydrochloric acid. The metal thus obtained was perceptibly whiter than the commercial article, also softer, more malleable, and had a fracture with some appearance of fibrous silkiness. Its specific gravity at 4° C. is 2.583. Its specific heat is 0.2253 as a mean for the range of temperature 0°–100° C. Attempts were made to roughly estimate the fusibility, and the pure metal seems to be a little less fusible than the commercial article. It also presents greater resistance to the prolonged action of solvents—acids and alkalis—than the impure metal. (*Chem. News*, XLVI, p. 178.)

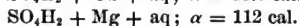
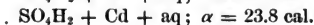
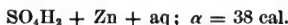
Iridium, according to Mr. John Holland, can be alloyed with phosphorus at a high heat, and the alloy fuses at a comparatively low temperature. The fused metal contains, according to Prof. F. W. Clarke, about 7½ per cent. of phosphorus. The phosphorus is removed by heating

in a Hessian crucible with lime. The iridium melted by this process is compact and crystalline; it is harder than the natural metal, being nearly as hard as the ruby; it has the color of steel and is not attacked by acids. (*Chem. News*, XLV, p. 168.)

Preparation and Properties of Metallic Cæsium.—Owing partly to the extreme scarcity of material Bunsen's attempts to obtain cæsium in metallic form were unsuccessful, but Carl Setterberg, availing himself of the tons of alums obtained in Marquart's establishment as a secondary product in the manufacture of lithium compounds from lepidolite, has isolated this rare metal and studied its properties. Setterberg prepared in 14 days 40 kilograms of rubidium alum and 10 kilograms of cæsium. He obtained metallic rubidium by decomposing the hydrogen-tartrate with calcium carbonate and sugar, in a mercury flask, but attempts to prepare cæsium by a similar process were futile. By the electrolysis of the cyanide of cæsium mixed with barium cyanide in the ratio of 4 molecules to one, Setterberg obtained the metal quite free from impurities. Metallic cæsium resembles closely the other alkali metals; is silver white, malleable, and very soft at ordinary temperatures. Thrown upon water it floats around and decomposes it with evolution of heat and light, in the same manner as potassium and rubidium. It inflames easily when exposed to the air unless protected by a film of oxide or by a layer of petroleum. The metal melts between 26°C . and 27°C .; its specific gravity is 1.88 at 15°C . Examined in the spectroscope it showed only traces of sodium as an impurity.

Setterberg failed to detect new elementary substances in the residues from which he extracted the rubidium and cæsium salts. (*Liebig's Annalen*, CCXI, p. 100.)

Nascent Hydrogen.—D. Tommasi, by numerous experiments on the reducing power of nascent hydrogen, has been led to the conclusion that its peculiar power varies with the reaction by which it is generated. Hence, hydrogen in a nascent state may be regarded as hydrogen + calories; or $\text{H} + \alpha$, in which α has different values according to the source of the hydrogen; thus:



The hydrogen increases in activity with the increase in value of α ; for sodium amalgam it is 112 cal. (*Bull. Soc. Chim.*, XXXVIII, p. 150.)

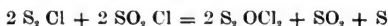
Preparation of pure Nitrogen.—Attempts to remove the last traces of oxygen from atmospheric air by means of phosphorus, potassium pyrogallate, hyposulphites, potassiumsodium alloy, and red-hot copper proving unavailing, Dr. Walter Flight found that it can be effected by passing the gas over a large surface of freshly precipitated ferrous hydrate. The latter reagent he prepares by adding a strong solution of 80 grams

of caustic potash to one of 200 grams of ferrous sulphate. The nitrogen thus treated failed to develop a brown color with apotassium pyrogallate. (*Chem. News*, XLV, p. 105.)

Behavior of Nitrogen in the Distillation of Coal.—Text-books usually state that coal contains about 2 per cent. of nitrogen, which comes off as ammonia when the coal is heated in closed vessels. Prof. W. Foster, however, finds that only a small fraction of the total nitrogen comes off as ammonia. In an experiment with coal containing 1.73 per cent. of nitrogen, only 14.5 per cent. of this amount was evolved as ammonia, 1.56 per cent. as cyanogen, 35.26 remained unaltered, and 48.68 of the whole amount remained in the coke. (*Chem. News*, XLV, p. 299.)

Presence of Arsenic in Bismuth Subnitrate.—Of fourteen samples of bismuth subnitrate examined by R. H. Chittenden and S. W. Lambert, only one was found to be perfectly free from arsenic. The average content of poison in the samples was .013 per cent. or 13 mgms. (about two-tenths of a grain) of As_2O_3 in 100 grams of bismuth. The subnitrate of bismuth is extensively used in medicine, and though it may not contain arsenic in sufficient quantity to be in itself injurious, the presence of the poison is greatly to be deplored. Fortunately, as the further experiments of the authors show, the arsenic is not readily absorbed into the system when combined with the bismuth preparation. (*Am. Chem. J.*, III, p. 396.)

A new Oxichloride of Sulphur.—J. Ogier, by heating to 250° C. in sealed tubes a mixture of equal weights of chloride of sulphur and chloride of sulphuryle, obtained the body S_2OCl_2 ; it forms a dark red liquid, boiling at 60° and having a specific gravity at 0° of 1.656. Its formation is explained by the equation:

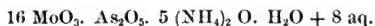


It is decomposed by water, forming a precipitate of sulphur, sulphurous anhydride, sulphuric acid, hydrochloric acid, and thio-acids. (*Bull. Soc. Chim.*, XXXVII, p. 293.)

An abundant source of selenium, according to P. Kienlen, exists in the crude hydrochloric acid condensed in Glover's towers. The selenium is derived from the pyrites, and being volatile at a red heat is carried over by the hydrochloric acid gas during the calcination of the salt cake, and condenses in the first recipients in the form of a reddish mud; this mud, when dried, contains in some cases from 41 to 45 per cent. of selenium. The author extracts the selenium from this deposit by acting upon it with chlorine, which converts it into a tetrachloride, and this, in the presence of water and chlorine, is transformed into selenic acid. The acid liquid obtained is then precipitated with hydrogen sodium sulphite and purified. (*Bull. Soc. Chm.*, XXXVII, p. 441.)

Presence of Tellurium in Copper.—Prof. Th. Egleston has detected tellurium in commercial copper to the extent of about 0.1 per cent. A surprisingly small quantity renders the copper red-short, and consequently worthless for rolling. (*Trans. Am. Inst. Mining Engineers*, Harrisburg Meeting, Oct., 1882.)

Complex inorganic Acids.—Dr. Wolcott Gibbs has published a continuation of his remarkable researches on the complex inorganic acids. He has demonstrated that inorganic compounds possess an unexpected degree of complexity, and has entered a very wide field of research, yielding a rich harvest. After discussing in detail several phospho-molybdates, he describes the preparation of the arsenio-molybdate having the composition:



The study of these two series (phospho- and arsenio-molybdates) leads to the following general results:

1. The phospho-molybdates form a series of which the lowest term contains five atoms of molybdic to one of phosphoric oxide, and the highest twenty-four atoms of the former to one of the latter.

2. As in the case of the phospho-tungstates, the greater number of the molybdenum compounds contain an even number of atoms of tungstic acid. The homologizing term is, therefore, 2 MoO_3 for these cases.

3. By far the greater number of phospho-molybdates contain *three* atoms of fixed base (old style), or, in more modern language, may be considered as derived from acids containing *six* atoms of hydroxyl. Anhydrous compounds of this type occur, and are not always simply residues obtained by heating salts which may be considered as acid, as containing, for example, $3 \text{ R}_2\text{O} \cdot 3 \text{ H}_2\text{O}$. It seems, therefore, necessary to admit the existence of acids of the general type $n \text{ MoO}_3 \cdot \text{ P}_2\text{O}_5 \cdot 3 \text{ H}_2\text{O}$.

4. On the other hand, while no single phospho-molybdate containing more than three atoms of fixed base for one of phosphoric oxide has been obtained in a state of indubitable purity, there is probably at least one salt with *six* or more atoms of fixed base, viz:



5. Negative evidence concerning the probable non-existence of a series of phospho- or arsenio-molybdates containing more than *three* atoms of fixed base, must not be too highly regarded.

6. As in the case of the phospho-tungstates, there exists a class of phospho-molybdates in which the ratio of the number of atoms of base to that of the number of atoms of phosphoric oxide is as 5:2, the number of atoms of molybdic oxide being even.

Dr. Gibbs presents a series of structural formulæ which explain all degrees of basicity which appear to be possible under the general conditions of the problem. For these and other details we refer to his original paper. (*Am. Chem. J.*, 111, p. 402.)

Constitution of Bleaching Powder.—Chemists have devoted much labor to the determination of the exact constitution of bleaching powder, and have arrived at results expressed in a great variety of formulæ.

Thorpe gives: $\text{Ca}^3\text{H}_6\text{O}_6\text{Cl}_4$ ($= \text{CaCl}_2\text{O}_2 + \text{CaCl}_2 + \text{CaH}_2\text{O}_2 + 2 \text{H}_2\text{O}$); Rose gives: $(\text{CaCl}_2, \text{Ca}_2\text{O}_2) \text{CaO}_2\text{Cl}_2 + 4 \text{H}_2\text{O}$; Kolb after a very thorough investigation: $(2 \text{CaO}_1\text{Cl}_2\text{H}_2\text{O}), \text{CaH}_2\text{O}_2$. Odling proposed the formula

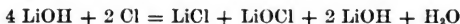


and this view has been quite generally adopted. Stahlschmidt regards bleaching powder as calcium hydroxychloride,



i. e., calcium hydroxide, CaH_2O_2 in which one atom of hydrogen is replaced by chlorine.

The question has been again investigated by Dr. Karl Kraut, who examined the action of chlorine on lithium hydroxide and obtained a compound very similar to the calcium analogue. When chlorine gas was brought in contact with the melted lithium hydroxide, the latter increased only 1 per cent. in weight in $4\frac{1}{2}$ hours, but by the addition of crystallized lithia in such quantities that the mixture contained about 1.4 per cent. H_2O the action of the chlorine was hastened. The reaction is as follows:



This equation was confirmed by analysis of the product. The lithium bleaching powder reacts with carbonic anhydride exactly like the calcium compound, i. e., it is decomposed with liberation of chlorine. It also behaves with chlorine just like the calcium compound. Since, however, lithium is a mono-valent element, one atom of the metal cannot simultaneously bind chlorine and the radical of hypochlorous acid, and Odling's manner of representing the constitution of bleaching powder is inapplicable. Besides, the lithium bleaching powder contains lithium chloride ready formed. The author therefore concludes that bleaching powder is a mixture of calcium hypochlorite, calcium chloride, and calcium hydrate. (Liebig's *Annalen*, CCXIV, p. 354.)

Lead peroxide can be advantageously prepared, according to Fehrmann, by decomposing a concentrated solution of chloride of lead at 50° or 60°C . with a solution of bleaching powder. The latter is added until the filtrate no longer shows a brown color when tested with an additional quantity of the bleaching powder. The lead peroxide is well washed and collected on a filter. It is nearly black, and very pure. The acetate of lead does not yield such good results as the chloride. (*Berichte d. chem. Ges.*, XV, p. 1882.)

Determination of Organic Matter in Potable Water.

Prof. J. W. Mallet, in compliance with the instructions of the National Board of Health, has made a thorough investigation of the chemical methods in use for the determination of organic matter in the potable waters. Assisted by Mr. W. A. Noyes, Dr. Charles Smart, and Dr. J. A. Tanner, he examined the merits and demerits of the "combustion process," the "albuminoid-ammonia process," and the "permanganate process." The special conclusions as to the combustion process may be briefly stated: The combustion itself, carried out according to Frankland's directions, is a process of great delicacy and satisfactory in trained hands; it requires constant practice to secure good results; the defective point is the failure of the evaporation to leave a residue representing the original organic matter of the water, a loss in carbon and a gain in nitrogen being constant errors; the dissociation of ammonia salts during the evaporation occasions a loss of nitrogen; in the presence of nitrates the difficulties of combustion are great and as yet insuperable; finally, the combustion process cannot be considered as "determining" the carbon and nitrogen of the organic matter in water in a sense to justify the claim of "absolute" value for its results which has been denied to those of all other methods.

The special conclusions as to the albuminoid-ammonia process are as follows: In the determination of both "free" and "albuminoid" ammonia there is a loss resulting from imperfect condensation of the ammonia during distillation; when urea is present some ammonia is easily formed by boiling with sodium carbonate, and this vitiates the determination of "free" ammonia; in the distillation with alkaline permanganates the nitrogenous matter sometimes fails to be completely acted upon before the contents of the retort is nearly reduced to dryness, and great uncertainty results; the value of the results by this process depends more upon watching the *progress* and *rate* of evolution of the ammonia than upon determining its total amount.

The special conclusions as to the permanganate process are: The results obtained by the Tidy method, and by Kubel's modification of the same, differ irregularly, the latter usually giving much higher figures; the results obtained by the Tidy process are liable to variations with the atmospheric temperature prevailing at the time the process is applied; the amount of oxygen consumed cannot be taken as a measure either of the organic carbon or of the total organic matter, though a general resemblance may be traced between strongly marked results, high or low, for the consumption of oxygen on the one hand and inorganic carbon (by the combustion process) on the other; the process is capable of giving more valuable information by watching the *rate* and *progress* of the oxidation of organic matter present than by any single determination of the absolute amount of oxygen consumed in a given time. (*Am. Chem. J.*, IV, p. 341.)

Use of Quicklime in Blasting.

An interesting application of the force resulting from the expansion due to hydration is recorded in *Nature*. To obviate the danger attending the use of explosive substances in coal mines, the following process has been successfully employed in Derbyshire; A series of holes six feet apart and about three feet in depth are drilled into the coal at the proper points; these holes are then filled with cylinders of compressed quicklime, each $2\frac{1}{2}$ inches in diameter and $4\frac{1}{2}$ inches long; each hole receives seven of these blocks. A groove in each cylinder admits the insertion of a $\frac{1}{2}$ -inch pipe which extends a few inches beyond the aperture of the drilled hole; through this pipe water is forced by a small hand pump. Each hole is of course firmly tamped with paper and rubbish. Soon after the water is introduced a sound as of escaping steam is heard, here and there the tamping is blown out, and in a few minutes the whole mass of coal is thrown out from the face upon "sprags," short timber props placed to receive it. The time required in the various operations is as follows: drilling 12 minutes, charging 4 minutes, watering 2 minutes, total 17 minutes for each bore-hole. (*Nature*, XXVI, p. 298.)

ORGANIC CHEMISTRY.

Formaldehyde (or oxymethylene) has acquired great importance within a short period, the researches of Baeyer, Wurtz, and others having shown that it forms an intermediate product between carbonic acid and carbo-hydrates in the physiology of plant-life. It may be regarded as the first product of the assimilation of carbonic acid by plants, and by simple polymerization and elimination of water, is probably capable of producing sugar, glucose, starch, and cellulose.

B. Tollens has described a convenient method for preparing this substance, which is based upon the oxidation of methylalcohol by air and incandescent platinum. For details we refer to the original paper. (*Berichte d. chem. Ges.*, XV, p. 1629.)

Curcumin and other Substances from Turmeric.—C. Loring Jackson and A. E. Menke give the following: Bengal turmeric root is ground and treated in an extractor with ligroine to remove turmeric oil, and then the curcumin, mixed with a large quantity of resin, is extracted with ether and finally purified by crystallization from alcohol. The average yield of curcumin was 0.3 of one per cent. The mean of five analyses indicates the following composition:

Carbon.....	68.30
Hydrogen.....	5.63

Curcumin crystallizes from alcohol in stout needles often in radiating groups. It has an orange to yellow color with a blue reflex; its ether solution fluoresces green; it melts at 178° C. It is nearly insoluble in water, slightly in benzol, readily soluble in hot alcohol, and more read-

ily soluble in glacial acetic acid; dissolved in strong sulphuric acid it blackens by charring; it is readily soluble in alkalis and alkaline carbonates. It forms two potassium salts $K_2 C_{14} H_{12} O_4$ and $K C_{14} H_{13} O_4$, as well as calcium, zinc and barium salts, the last named being insoluble. By a study of the esters of curcumin the authors definitely establish $C_{14} H_{14} O_4$ as the true formula. The results of incomplete oxidation are most interesting; by treating an aqueous alkaline solution with potassium permanganate, not in excess, a strong smell of vanilla was observed. Further treatment effected the separation of an oil, gradually solidifying in circular groups of radiating needles, and having a strong odor of vanilla. By sublimation and purification of this product, white needles of vanillin, melting at $78^\circ C.$, were obtained. The yield was very small. The authors also show that diethylcurcumin yields by oxidation ethylvanillic acid. (*Am. Chem. Journ.*, IV, p. 77.)

Urea, its Synthesis and its Estimation.—Fenton has succeeded in transforming urea into cyanamide; the dehydration was effected by means of sodium in accordance with the reaction:



Prof. W. G. Mixer has succeeded in forming urea by the reaction of ammonia on carbonic anhydride at a red heat. The urea forms slowly, 2 to 3 decigrams per hour, and collects in fine crystals in the cooler parts of the tube through which the gases are conducted. He regards the formation of urea, as preceded by that of cyanic acid, thus: $\text{CO}_2 + \text{NH}_3 = \text{HCNO} + \text{H}_2 \text{O}$. The cyanic acid probably unites with ammonia in the cooler part of the tube to form urea. (*Am. Chem. J.*, IV, p. 35.)

J. R. Duggan described a modification of Knop's process of estimating urea by the amount of nitrogen evolved on the addition of an alkaline hypobromite. His method consists in mixing the urea and caustic soda solutions first and then adding the bromine. He employs a caustic soda solution made by dissolving 20 grms. of sodium hydrate in 100 c. c. of water; and with each 20 c. c. of this he uses 1 c. c. of bromine. The results are satisfactory. The weight of nitrogen multiplied by 2.143 gives the amount of urea. (*Am. Chem. J.*, IV, p. 47.)

Dr. Theodore G. Wormly has also investigated the above method of determining urea and finds that only under the following conditions is the whole of the nitrogen uniformly set free: 1st. The reagent (hypobromite) should be freshly prepared; 2d. The urea solution should be wholly added to the reagent; 3d. The amount of urea operated upon should not exceed 1 part to about 1,200 parts of the diluted reagent; 4th. When comparatively large amounts of urea are present the surrounding temperature should not be less than about $20^\circ C.$ (68°Fah.). (*Chem. News*, XLV, p. 27.)

Acrolein Urea.—Hugo Schiff has described under the name acryldiureide, a body resulting from the union of two molecules of urea and one of acrolein: Prof. A. R. Leeds has obtained a body having the same

constitution, $\text{CO}(\text{NH})_2\text{C}_3\text{H}_4$. It forms a white amorphous substance, slightly soluble in alcohol, ether, chloroform, and carbon-disulphide. Dr. Leeds points out some irrational conclusions in Schiff's paper, and accounts for them by presuming that Schiff operated upon imperfectly purified material. (*Berichte d. chem. Ges.*, xv, p. 1159.)

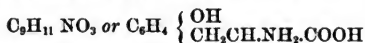
Synthesis of Uric Acid.—This interesting synthesis has been accomplished by Prof. Johann Horbaczewski. Pure, finely powdered glyco-coll (made from hippuric acid) is mixed with ten parts of pure urea (made from ammonium cyanate) and heated in a flask to 200° to 230°C ., until the material becomes brownish-yellow and viscous. After cooling the mass is dissolved in diluted potassium hydroxide, saturated with ammonium chloride, and precipitated with a mixture of ammoniacal silver nitrate and magnesia mixture. The precipitate, which contains the uric acid, is well washed with ammonia water and treated with potassium sulphide. The filtrate is then over-neutralized with hydrochloric acid and boiled down to a small bulk. The raw material thus obtained is purified by solution in potassium hydroxide, and after repeating the operation, the yellowish crystalline powder is washed with alcohol, dried with carbon disulphide (to remove the sulphur), and finally with ether. This purified material exhibits all the properties and reactions of uric acid. The author is engaged in a further study of this synthetical reaction. (*Berichte d. chem. Ges.* xv, p. 2678.)

Synthesis of a new Amido-Acid analogous to Hippuric Acid.—By the action of silver glycocollate on benzoylchloride, Th. Curtins has obtained three acids, ordinary hippuric acid, hippurylglycocoll, and a third of unknown constitution having the empirical formula $\text{C}_{10}\text{H}_{12}\text{N}_3\text{O}_4$. The hippurylglycocoll or hippurylamidoacetic acid crystallizes from hot water in rhombic tables or needles which melt without decomposition at $206^\circ.5\text{C}$. The new acid crystallizes in microscopic needles which become brown when heated to 230° , and are decomposed at 240°C . (*Journal prak. Chem. N. F.*, xxvi, p. 145.)

Synthesis of Tyrosine.—Tyrosine forms a crystalline nitrogenous body existing in the animal organism (spleen, liver, urine, &c.), produced by the decomposition of albuminoid substances. It has long been studied by chemists; Liebig obtained it by acting on decomposing caseine with melted potash, Müller found it in putrefying yeast, Hinterberger prepared it by boiling oxhorn with sulphuric acid, and its constitution has been discussed by several authors. In 1869 L. Barth pointed out that tyrosine could be regarded as a parahydroxyphenylamidopropionic acid, but his attempts to prepare it, as well as the proposed reactions of Beilstein and Kuhlberg, were unsuccessful.

Erlenmeyer has been engaged for several years in experimenting in this direction, and with the assistance of Dr. A. Lipp has at length accomplished this interesting synthesis. The process is as follows:

Phenylalanin (phenyl- α -amidopropionic acid) is converted into paranitrophenylalanin by the action of sulphuric and nitric acids, and this product is transformed into paraamidophenylalanin by means of tin and hydrochloric acid. The chloride of this diamido compound is treated in alcoholic solution with nitrous acid and the resulting body heated with water. On evaporating and treating the residue with ether a sirupy liquid is obtained which is probably parahydroxyphenyllactic acid. This product is supersaturated with ammonia and concentrated by evaporation, which gives a crystalline mass showing under the microscope the crystalline characters of tyrosine. By recrystallizing from dilute boiling alcohol the material is purified. Analysis shows it to have the exact constitution of tyrosine:



(*Berichte d. chem. Ges.*, xv, pp. 1006 and 1544.)

Synthesis of Anthracene and Phenanthrene from Orthobrombenzyl-bromide.—C. Loring Jackson and J. Fleming White, with a view to settling the exact constitution of anthracene, have studied the action of sodium on orthobrombenzyl-bromide, and obtained anthracene and phenanthrene. The former was identified by its melting point (212°), by the formation of anthraquinone (melting at 273°), and of alizarine; the latter was identified by the melting point of its quinone, 198° , and by Laubheimer's test. Dibenzyl also forms in this reaction, and an oil of uncertain composition, possibly benzyltoluol.

By this synthesis it is proved that the two connecting carbon atoms in the benzol rings are attached to each ring in the ortho-position, and the last doubt about the constitution of anthracene is removed. (*Chem. News*, XLVI, p. 44.)

Synthesis of Organic Bodies by the Electrolysis of Water and Solutions with Electrodes of Carbon.—A. Bartoli and G. Papasogli, in researches on galvanic polarities, had observed that coke, charcoal, or graphite, under the action of the current, is disaggregated; the electrolyte is blackened more or less, according to its nature and that of the carbon, and the gas evolved at the positive pole is below the normal volume. The authors undertook the present investigation to ascertain what becomes of the oxygen. They experimented with graphite, coke, and wood charcoal, purified by chlorine at high temperatures. With coke or charcoal as positive electrode and distilled water as electrolyte and a battery of 1,200 Daniell cells, they remarked after two days a brown color in the electrolyte and an acid reaction. The battery was then reduced to 100 Bunsen cells, and ten days later to 20 Bunsen cells; these were in operation for 30 days. The water became black; the electrode, which weighed about 500 grams, was totally disaggregated, and a thick muddy deposit was formed. The electrolyte was found to contain

mellitic acid and some of its derivatives, such as the hydro-mellitic, pyro-mellitic, and hydro-pyro-mellitic acids.

The muddy deposit contained a black substance soluble in hot water and alkalis, but insoluble in most mineral acids and in the majority of organic solvents. The authors named this body mellogen, since, on oxidation, it yields acids of the benzo-carbonic series. It has the composition $C_{14}H_2O_4$. (*Comptes Rendus*, May 15, 1882.)

Acetoxims.—By the action of acetone on hydroxylamin, Alois Janny has obtained the first member of a new series of bodies, for which series he proposes the name of acetoxims. This name is applied to bodies containing the group $=CNOH$ united on two sides to carbon. When only one bond of the carbon group is united to carbon and the other to hydrogen, derivatives of aldehyde are formed for which the name aldoxims is suggested.

The simplest body of the acetoxims is dinethylacetoxim, having the formula $CH_3-C(NHO)-CH_3$. This is obtained by mixing an aqueous solution of hydroxylamine with acetone and extracting ether, which leaves, on evaporation, brilliant white, hard, volatile, prismatic crystals. It is soluble in water, alcohol, ether, &c., and melts at 59° to 60° C., distilling without decomposition at $134^\circ.8$ C. It is a neutral substance, and has a slight odor, resembling chloral.

The author has also prepared and studied ethyl-methylacetoxim, methylpseudobutylacetoxim, and some analogous phenyl derivatives. (*Berichte d. chem. Ges.*, xv, pp. 1324 and 2778.)

Diphenylaminacroleine has been prepared by Prof. Albert R. Leeds by heating an alcoholic solution of diphenylamine with an excess of acroleine. After a few hours' digestion a heavy red precipitate forms, soluble in boiling alcohol, together with a sticky insoluble mass. The latter is treated with alcohol and water until it becomes pulverulent and capable of being powdered in a mortar. This amorphous substance proves to be diphenylaminacroleine ($C_{19}H_{10}N$), C_3H_4 . It does not fuse nor sublime, but is decomposed, on heating, into a carbonaceous mass. It is insoluble in ether, slightly soluble in alcohol and acetic acid, and soluble in chloroform, yielding a dark red liquid. It could not be obtained in crystals. Bromine converts it into a bromo-compound, also amorphous, and not further examined.

Homoquinine, a new Alkaloid.—Howard and Hodgkin have obtained a new alkaloid from cinchona bark, for which they propose the name *homoquinine*. Its properties are similar to those of quinine, having the same specific rotary power, and nearly the same composition, but it crystallizes from ether more readily, and differs in the solubility of its salts. One part of the sulphate of homoquinine requires more than 100 of water for solution. Alcohol of 90 per cent. dissolves 7.64 parts of the alkaloid, a 5 per cent. solution of which shows a rotation of -158° . (*J. Chem. Soc.*, xli, p. 66.)

Iodide of Bismuth and Potassium as a Reagent for Alkaloids.—F. Mangini prepares this reagent by mixing 3 parts of iodide of potassium with 16 of iodide of bismuth (liquid) and 3 parts of hydrochloric acid. Thus prepared it is not decomposed by water and gives characteristic phenomena with many alkaloids.

Strychnine, a light-yellow precipitate, limpid solution; after standing the precipitate turns dark yellow. One part of strychnine in 500,000 of water can be detected.

Brucine, a golden-yellow silky precipitate becoming lighter in color.

Morphine, a reddish-yellow precipitate disappearing after some days, when the liquid becomes canary-yellow.

Codeine, a yellowish-red precipitate turning brick-red on standing.

Narceine, a light-yellow precipitate remaining a long time suspended in the liquid; it turns reddish-yellow on standing.

Atropine, a silky precipitate, which settles as a reddish-yellow powder; on standing the precipitate turns canary-yellow and slowly dissolves, coloring the liquid golden yellow.

Aconitine, a flaky precipitate, which settles as a chrome-yellow powder; no change on standing.

Nicotine, a red pulverulent precipitate, becoming reddish-yellow.

Conicine, a red pulverulent precipitate of a more intense color than the preceding, and becoming dirty white on standing.

Solanine, a golden-yellow precipitate forming slowly, and turning darker.

Veratrine, a light-yellow precipitate, turning lighter.

Quinine sulphate, a brick-red precipitate, turning dirty white.

Cinchonine sulphate, like the preceding, but darker after standing. (*Gazzetta Chimica Italiana*, 1882, p. 155, and abstract in *Bull. Soc. Chim.*, xxxviii, p. 670.)

Application of Electrolysis to Dyeing.—Dr. Frederic Goppelsroeder, of Mühlhausen, has extended the application of electrolysis to the formation of coloring matters and to the art of dyeing. He has employed the galvanic current in producing and simultaneously fixing dyes on various textile fabrics, in preventing the oxidation of colors during the printing, and in preparing solutions of *reduced* dye-stuffs, the so-called blue-vats. To obtain, for example, an aniline black on a fabric or on paper, the stuff is soaked in an aqueous solution of a salt of aniline (the chloride is preferred), and then placed on an unoxidizable metallic plate connected with one pole of a galvanic battery or with a small dynamo machine. A second metallic plate, bearing in relief the design and connected with the other pole, is then placed upon the stuff. By pressing gently and passing the current of electricity a black design is formed. Medals and coins may be copied in a similar manner. By drawing lines on the paper or fabric impregnated with the aniline salt, with a piece of carbon forming one of the poles, or with a non-oxidizable metal, black

lines are obtained whenever the presence of the conducting carbon permits the passage of electricity.

Hydrogen generated at the negative pole may be employed instead of zinc, ferrous sulphate, glucose, hydrosulphite, and the other common agents, to reduce baths of indigo, of aniline black, &c. A feeble continuous current gives the best results. The two electrodes must be separated completely. Dr. Goppelsroeder expresses the hope that his experiments may eventually become of industrial importance. (Reprinted from *L'Electricien*, and communicated by the author.)

Method and Apparatus for Testing Inflammable Oils.—In accordance with the instructions of the New York State Board of Health to its sanitary committee, and in response to an order of said committee, Arthur H. Elliott has made an exhaustive report on the methods and apparatus for testing inflammable oils, with special reference to dangerous kerosene. The investigations were made with the ultimate intention of establishing a standard for testing petroleum in New York State. Mr. Elliott examined thirteen kinds of testers, including three open testers, and some electric testers, and experimented with four different samples of oil on each apparatus. His tests show that it is very important to know which apparatus has been used when an oil is said to have a given flashing point. One of the oils showed a range of temperature from 95° to 130° F. The general conclusions to which Mr. Elliott comes are briefly as follows: Of all the 13 apparatuses not one can be called perfectly satisfactory; open testers are entirely untrustworthy for determining the safety of kerosene oil; of the closed testers the Wisconsin State tester, with a few alterations suggested by the author, gives the most reliable results. The electric testers are troublesome to keep in order. (*Second Annual Report of the State Board of Health of New York, Albany, 1882, p. 449.*)

"Benzol" or "Benzene," a Question in Nomenclature.—Attention is being directed to the necessity of greater uniformity in nomenclature, especially as regards the important hydrocarbons C_6H_6 and $C_{10}H_8$. German, French, and most American chemists designate C_6H_6 by the name *benzol* (sometimes spelled with a superfluous final *e*), while English chemists use the term *benzene*; in like manner continental chemists name $C_{10}H_8$ *naphthalin*, and Englishmen call it *naphthalene*.

A few years ago the London Chemical Society issued a six-page pamphlet* to its corps of abstractors giving rules of nomenclature and notation, and this has materially aided in securing uniformity. In preparing a paper for the *Berichte der deutschen chemischen Gesellschaft*, on the "Laws of Substitution in the Naphthalene Series," Prof. Henry E. Armstrong, of the London Institution, employed the customary English terms, and desired the publication committee to refrain from changing them. This led to correspondence which is published in the *Berichte* (vol. xv, p.

* Reprinted in *Chemical News* (1883), vol. XLVII, p. 15.

200). Professor Armstrong objects to the termination *ol* for hydrocarbons not of the paraffin series, and would restrict it to the alcohols—carbinol, phenol, &c. He calls attention to the confusion which results from the terms “ethylene,” “anthracene,” “phenanthrene,” on the one hand, and “benzol,” “toluol,” and “naphthalin” on the other; and he expresses the hope that the German Chemical Society may unite with the London organization in attempting a uniform nomenclature. The publication committee of the *Berichte* approved of an exchange of views on the question.

American chemists are vitally interested, for in this country the occurrence of the petroleum product called benzine complicates the matter. While the English custom has much in its favor, the similarity in pronunciation of “benzine” and “benzene” leads many Americans to follow the continental terminology. Consistency is eminently desirable. It will be interesting to watch the result of the movement.

The *Berichte d. chem. Ges.* for 1882 contains articles on the nomenclature of special groups. We refer to Herrmann on the nomenclature of azo-compounds (p. 813), and to Wallach’s paper on the same subject. Liebig’s *Annalen* also has a paper, by Aug. Bernthsen, on the nomenclature of derivatives of carbonic acid. (Liebig’s *Annalen*, CCXI, p. 85.)

NOTES.

Black phosphorus is formed, according to Maumené, when phosphorus is distilled in hydrogen (made from zinc and sulphuric acid), and not formed when the distillation is conducted in carbonic anhydride. The black color soon disappears.

Lecture experiment.—H. Schwarz finds that zinc dust and sulphur, when intimately mixed, combine with very great energy, and the experiment is more brilliant and interesting than the usual one with iron filings (or copper turnings) and sulphur. The best proportions are two parts by weight of zinc and one of sulphur. The mixture inflames also when struck heavily by a hammer, and when ignited in a confined space (gun-barrel) explodes with about one-fourth the energy of gunpowder.

The rare metal vanadium occurs in large quantity, according to Witz and Osmond, in the residues of the iron furnaces of Creusot, and they describe a process for extracting it on a large scale with a view to its industrial applications.

Solid paraffine has been discovered by Silvestri in basalt. It occurs in cavities about a centimeter in diameter, and is nearly identical with the paraffine occurring in petroleum.

Bernthsen has discussed the unsatisfactory nomenclature of the isomeric sulpho-derivatives of carbonic acid, and proposes to call the radical =C=S *thio-carbonyl*, and to name the acids thio-carbonyl acids. In like manner we may have for =C=NH imido carbonyl and similar derivatives.

Phosphate of chromium, prepared by the action of phosphoric acid and

sodium hyposulphite on chromates of the alkalies, forms a fine green pigment, which is proposed by Ad. Carnot as a substitute for the injurious arsenical and cupriferos colors.

Paul Sabatier has published a note claiming priority over A. Colson in the discovery of the *sylyphides of silicium*, Si S , and Si SO .

Constantine Fahlberg has patented a process for preparing sulphate of aluminium free of iron for the mineral bauxite. The essential point in the method is the use of lead peroxide for the removal of the iron; the lead compound being afterwards recovered in a very simple manner.

Hautefeuille and Chappuis have studied the formation of pernitric oxide, and assign to it the formula N_2O_6 .

Cailletet has obtained a crystalline hydrate of phosphoretted hydrogen by strongly compressing the gas in the presence of water and then suddenly decreasing the pressure. Hydrates of ammonia and of sulphuretted hydrogen have also been obtained by this method.

Wroblewski, by a somewhat similar method, has obtained a solid crystalline hydrate of carbonic anhydride, $\text{Co}_2 \cdot 8\text{H}_2\text{O}$.

In a letter to Nature, G. F. Rodwell revives the controversy concerning the relative claims of Lavoisier and of Priestley to the discovery of oxygen. Rodwell endeavors to give the greater honor to Lavoisier.

Hydroxylamine is found by G. Bertonni and C. Raimondi to be an active poison when injected into the blood. Less than 0.2 gram killed a medium-sized dog. It also exerts a poisonous effect when introduced into the stomach or under the skin. The blood assumes a chocolate color and yields on dialysis nitrous acid, an oxidation product of hydroxylamine.

Two new antiseptics, calcium- and sodium-glycero-borates, have been announced by G. Le Bon, and experiments prove their utility. They are odorless and without injurious action on the most delicate tissues.

The discovery of hydrogen, NH_2 , claimed by Maumené, has been denied by several chemists who repeated the process (action of potassium permanganate on ammonium oxalate) and obtained negative results.

Bromo-sulphide of carbon has been discovered by Carl Hell and Fr. Urech. It is obtained by the direct action of bromine on carbon disulphide, and forms small brilliant prismatic crystals having the composition $\text{C}_2\text{S}_3\text{Br}_6$.

Rose's fusible alloy has been prepared by W. Spring by subjecting the constituents (lead, bismuth, and tin) in their proper proportion, to enormous pressure. Wood's alloy, melting at 65°C . can be obtained in a similar manner. The pressure employed was 7,500 atmospheres.

Metallic uranium, according to Zimmermann, forms a silver-white, somewhat malleable metal, very hard, but scratched by steel. It has a specific gravity of 18.7. It burns with brilliant light and scintillations, forming a bulky oxide. It is slowly attacked by warm nitric acid and by sulphuric acid, and readily dissolves in hydrochloric.

The Royal Society awarded the Davy medal (in duplicate) to D. Men-

delejeff and to Lothar Meyer for their discovery of the periodic relations of the atomic weights. This has drawn out a protest from John A. R. Newlands, of London, who claims priority in the publication of the periodic law, and who produces evidences of his assertion. (*Chem. News*, 46, 278.)

The French Academy of Sciences offer the new Volta prize of 50,000 francs to the author of the discovery which shall enable electricity to be applied economically in one of the following directions: as a source of heat, of light, of chemical action, of mechanical power; as a means of the transmission of intelligence, or of the treatment of disease. Competition is open until June 30, 1887, to scientific men of all nations, and the award will be decided in December, 1887.

The German Chemical Society is in a very flourishing condition. At the close of 1882 it numbered 2,527 members, of whom 16 are honorary and 263 associate members. The *Berichte*, published annually by the society, forms one of the most important of chemical journals; the two volumes issued in 1881 comprise over 3,000 pages, and the volumes for 1882 attain about the same size. The total income of the society for 1882 amounted to 56,247 marks, and the expenses for the same period were 44,697 marks.

Necrology.—During the year 1882 the deaths of many eminent chemists were recorded. Among them may be mentioned: Dr. John W. Draper, of New York; Dr. Henry Draper, of New York; Prof. William B. Rogers, of Boston; Dr. John Stenhouse, of Manchester; Prof. Rudolph Böttger, of Frankfort; Dr. Ludwig Feder, of Munich; Prof. A. Popoff, of Warsaw; Prof. Friedrich Wöhler, of Göttingen.

AN ACCOUNT OF THE PROGRESS

IN

C H E M I S T R Y

IN

T H E Y E A R 1 8 8 3 .

BY

PROF. H. CARRINGTON BOLTON.

FROM THE SMITHSONIAN REPORT FOR 1883.

WASHINGTON:
GOVERNMENT PRINTING OFFICE
1884.

CHEMISTRY.

BY H. CARRINGTON BOLTON,
Professor of Chemistry, Trinity College, Hartford.

GENERAL AND PHYSICAL.

Possible Variability of the Law of Definite Proportions.—One of the most interesting subjects discussed during the year (1883) concerns the fundamental conceptions of chemical philosophy. The whole superstructure of modern chemistry rests upon the atomic theory and on the absolute character of that function of an element which we call atomic weight; hence, any proposition to throw discredit on these conceptions may well be regarded as revolutionary. The discussion was introduced by Prof. Adolph Wurtz, who presented to the *Société chimique de Paris* a summary of the views of Boutlerow; these were emphatically indorsed by Schützenberger, and have since elicited a communication from Prof. Josiah P. Cooke, jr., of Harvard College.

Schützenberger announced in 1880 or 1881 that in analyzing some hydrocarbons the sum of the carbon and hydrogen was 101 for 100 parts of material, the result under other conditions being normal. Boutlerow has called attention to this anomaly as illustrating views he has held for three years. He expresses the opinion that the chemical value of a constant weight (or rather mass) of a substance may vary, and that the so-called atomic weight of an element may be simply the carrier of a certain amount of chemical energy which is variable within narrow limits. He further asks the question whether Prout's hypothesis may not be a true law which, like that of Mariotte, admits of a limited variation. Numerous facts are cited, chiefly the results of quantitative analyses, which seem to confirm these views. If such views prevail, chemical combination can no longer be regarded as the juxtaposition of the definite invariable masses we call atoms, but must be considered as the reciprocal saturation or interpenetration of masses which may vary with the relative strength of their chemical energy acting at the time. Schützenberger, who took part in the discussion, enumerated many facts which led him to the conclusion that the law of definite proportions is not so absolute as generally supposed. We have space but for a single example: When water is synthesized by reduction of a known weight of CuO , by weighing the reduced copper and the water formed,

it is found that the ratio of O to H is not constant, but varies with the state of division and of saturation of the oxide, the duration of contact of the water formed with the oxide and with the temperature, from 7.95 to 8.15. The latter value is obtained with a saturated and divided oxide filling the tube; the former, with oxide in lumps filling the tube for a space of 25 centimeters. With a larger empty space the ratio has fallen to 7.90.

Prof. Josiah P. Cooke, jr., calls attention to the fact that he expressed similar views and fully worked them out more than twenty-five years ago. He quotes from his paper on "Two new crystalline compounds of zinc and antimony, and on the cause of the variation of composition observed in their crystals," published in the *Memoirs of the American Academy of Arts and Sciences* in 1855 (new series, vol. v., p. 337). He also refers to a paper published in the *American Journal of Science* (second series, xx, 1855) entitled "On an apparent perturbation of the law of definite proportions observed in the compounds of zinc and antimony." In these papers the opinions now under discussion were brought forward, not simply as speculations, but as a legitimate theory advanced to explain the facts observed in his investigations. Professor Cooke shows that as long since as 1855 he questioned the absolute character of the law of definite proportions; he then suggested that the variation is due to the very weak affinity between elements manifesting a fluctuating composition; and he wrote at that time, "To what extent this perturbation of the law of definite proportions prevails among chemical compounds future investigation must determine. There are, however, a number of facts which tend to prove that it is very general whenever chemical affinity is weak." Professor Cooke fully substantiates his claim to priority, and then proceeds to consider whether the progress of chemistry since 1855 has tended to confirm or to invalidate these views. He says, in conclusion, that he "feels that the weight of evidence is at present in favor of the atomic theory, and of that absolute definiteness of combining proportions which this theory involves;" yet at the same time he "is very glad that the whole question" is again open to discussion. "But, although it must be admitted that the atomic theory is the only basis on which a consistent philosophy of chemistry can at present be built," Professor Cooke confesses that "he is rather drawn to that view of nature which refers all differences between substances to dynamical causes, and which regards the atomic theory as only a temporary expedient for representing the facts of chemistry to the mind." (*Am. J. Sci.* (3), xxvi, 63 and 310.)

Atomic Weight Determinations.

Didymium.—Owing to the discrepancies in the existing figures for the atomic weight of didymium, B. Brauner has re-examined the subject. Cleve had previously assigned the figures 147.2, and Brauner himself had found 146.58. The latter undertook experiments to decide

which of the numbers represents, or more nearly approaches, the true atomic weight, and to ascertain whether pure didymium is a homogeneous body, or whether it can be split up into heterogeneous constituents, as has been proved to be the case with several metals of the rare earths. Brauner found by his new experiments $Di = 145.42$. This number differs much from that previously obtained by Brauner, who believes the discrepancy due to the elimination of an element of a higher atomic weight and of a less basic nature than didymium. This proved to be samarium, *q. v.* (*J. Chem. Soc.*, 1883, 278.)

P. T. Cleve has also examined this question, and having eliminated foreign bodies by fractional precipitation he obtained the value $Di = 142.33$, when $O = 16$. He had previously obtained (in 1874) $Di = 147.2$, but he attributes the discrepancy to the presence of the then unknown element samarium. (*Bull. soc. chem.*, XXXIX, 289.)

Samarium.—Brauner, in the course of his researches into the atomic weight of didymium, investigated the atomic weight of samarium, and assigns to it the value 150.7. (*J. Chem. Soc.*, 1883, 278.)

P. T. Cleve has also determined the atomic weight of samarium by converting the pure oxide Sm_2O_3 into the sulphate, and obtained from six closely agreeing experiments the value 150.021, or, in round numbers, 150. Cleve thinks samarium entitled to fill the eighth line, eighth group of Mendelejeff's Periodic System. (*J. Chem. Soc.*, 1883, 362.)

Lanthanum.—In 1874 P. T. Cleve found the atomic weight of $La = 139.$, figures which agreed well with determinations by Marignac and Brauner. More recent investigations by Brauner led to the value 138.28, and his researches seemed to denote the existence of a foreign oxide accompanying the lanthanum. Cleve himself was at one time inclined to admit the existence of such a substance by the observation of a blue ray ($\lambda = 4333.5$) in the spectrum of the fractions intermediate between lanthanum and didymium; but this ray proved to belong to lanthanum. To decide the question of the existence of this hypothetical body between La and Dd , Cleve submitted mixtures to several series of partial precipitations by dilute ammonia. His results give for La 138.019 ($O = 15.9633$). They also show that La is not split up, but is a homogeneous body. (*Bull. soc. chem.*, XXXIX, 151.)

Yttrium has again been examined by P. T. Cleve, who effected a more complete separation from terbium by precipitating the acid solution of the nitrate by means of oxalic acid. In the successive fractions thus obtained Cleve determined the atomic weight, which he places at 89.02 for Y^{III} , when $O = 16$. Determinations by the same author in 1872 gave him 89.485. (*Comptes rendus*, December 11, 1882.)

Thorium has been re-examined by L. F. Nilson, who determined its specific heat, and thence estimates the atomic weight at 232.4 for th^{IV} . (*Comptes rendus*, XCVI, p. 346.)

Lithium.—D. Tommasi, on purely theoretical grounds, thinks the atomic weight of Lithium in its compounds is double that which it possesses in a free state. He proposes for lithium chloride the formula LiCl_2 , bringing the metal into the family group Ba, Sr, and Ca, with which, in its compounds, it certainly bears many analogies. (*Cosmos, les mondes*, No. 2, 1883.)

Glucinum.—By determining anew the specific heat of metallic glucinum, Dr. T. S. Humpidge obtained the figures 0.4455, and this gives an atomic weight=13.65 instead of 9.1, as usually assigned. (*Chem. News*, XLVII, 181.)

Humpidge's results have been questioned by Dr. J. Emerson Reynolds, who shows that the material used by Humpidge was less pure than that used by Messrs. Nilson and Petterson. He thinks that the weight of evidence is in favor of the value 9.2 for the atomic weight, the metal being a dyad. To this criticism, however, Dr. Humpidge replies in a third article, maintaining the purity of the material used and rejecting Reynolds' views as to the valence of the element. (*Chem. News*, XLVII, p.297.)

Titanium.—The atomic weight of titanium has been carefully revised by Prof. T. E. Thorpe, who obtained as a mean of nineteen determinations $\text{Ti}=48.00$. (*Chem. News*, XLVIII, 251.)

Manganese.—Professors James Dewar and Alexander Scott, of Cambridge, England, have redetermined the atomic weight of manganese, and obtain as a mean of eight experiments the value 55.038 when $\text{O}=16$ and $\text{Ag}=107.93$. The methods employed were the reduction of silver permanganate by hydrogen (which, however, was unsatisfactory), and the reduction of the same salt by sulphurous acid, sodium formate, or potassium nitrite, and subsequent titration of the silver with dilute potassium bromide. (*Chem. News*, XLVII, 98.)

Marignac has also redetermined this constant, obtaining $\text{Mn}=55.07$. (*Archives des sci. phys. nat.* (3), X, 5.)

Antimony.—Bongartz has recently estimated anew the atomic weight of antimony by the method proposed by Classen. The average of twelve experiments was 120.193, which very closely approximates the results of Schneider and of Cooke. (*Ber. d. chem. Ges.*, XVI, 1942.)

Additional Redeterminations of Atomic Weights.

Nickel: $\text{Ni}=58.75$ by Baubigny. (*Comptes rendus*, XCVII, 951.)

Copper: $\text{Cu}=63.46$, by Baubigny. (*Comptes rendus*, XCVII, 906.)

Tellurium: $\text{Te}=125.0$ by Brauner. (*Ber. d. chem. Ges.*, XVI, 3055.)

Bismuth: $\text{Bi}=208.16$ by Marignac. (*Archives des sci. phys. nat.* (3), X, 5.) Also by Lowe, who obtained $\text{Bi}=207.33$. (*Zeitschr. anal. Chem.*, XXII, 489.)

Zinc: $\text{Zn}=65.29$ by Marignac. (*Archives des sci. phys. nat.* (3), X, 5.)

Magnesium: $\text{Mg}=24.37$ by Marignac. (*Archives des sci. phys. nat.* (3), X, 5.)

Atomic Weights of the Elements.

Lothar Meyer and K. Seubert have published a recalculation of the atomic weights of the elements from the original numbers. The values obtained differ but little from those previously published by F. W. Clarke (*Constants of Nature*, Part V), though they are not all identical. The following table may be usefully reprinted here, since it contains most reliable figures. All values whose possible error lies between 0.01 and 0.5 H are denoted by (a).

Name.	Symbol.	Atomic weight.	Name.	Symbol.	Atomic weight.
Aluminium	Al	(a) 27.04	Niobium or Colum- bium	Nb	93.7
Antimony	Sb	119.6	N	(a) 14.01	
Arsenic	As	(a) 74.9	Nitrogen	Ng	?
Barium	Ba	(a) 136.86	Norwegium	Os	195
Beryllium	Be	(a) 9.08	Osmium	O	(a) 15.96
Bismuth	Bi	207.5	Oxygen	Pd	106.2
Boron	B	(a) 10.9	Palladium	P	(a) 30.96
Bromine	Br	(a) 79.76	Phosphorus	Pt	(a) 194.3
Cadmium	Cd	(a) 111.7	Platinum	K	(a) 39.03
Caesium	Cs	(a) 132.7	Potassium	Rh	104.1
Calcium	Ca	(a) 39.91	Rhodium	Rb	(a) 85.2
Carbon	C	(a) 11.97	Rubidium	Ru	103.5
Cerium	Ce	141.2	Ruthenium	Sa	* ?
Chlorine	Cl	(a) 35.37	Samarium	Sc	(a) 43.97
Chromium	Cr	52.45	Scandium	Se	78.87
Cobalt	Co	58.6	Selenium	Si	28.0
Copper	Cu	(a) 63.18	Silicon	Ag	(a) 107.66
Decipium	Dp	?	Silver	Na	(a) 22.995
Didymium	Di	146.0	Sodium	Sr	(a) 87.3
Erbium	E	166	Strontium	S	(a) 31.98
Fluorine	F	(a) 19.06	Sulphur	Ta	182
Gallium	Ga	69.9	Tantalum	Te	† 127.7
Gold	Au	196.2	Tellurium	Tb	?
Hydrogen	H	(a) 1.00	Terbium	Tl	203.7
Indium	In	(a) 113.4	Thallium	Th	231.96
Iodine	I	(a) 126.54	Thorium	Tr	?
Iridium	Ir	(a) 192.5	Thulium	Sn	117.35
Iron	Fe	(a) 55.88	Tin	Ti	50.25
Lanthanum	La	138.5	Titanium	U	239.8
Lead	Pb	(a) 206.39	Uranium	V	(a) 51.1
Lithium	Li	(a) 7.01	Vanadium	W	(a) 183.6
Magnesium	Mg	23.94	Wolfram (Tungsten) ..		?
Manganese	Mn	54.8	Y α and Y β	Yb	172.6
Mercury	Hg	(a) 199.8	Ytterbium	Y	89.6
Molybdenum	Mo	(a) 95.9	Yttrium	Zn	64.88
Mosandrium	Ms	?	Zinc	Zr	90.4
Nickel	Ni	(a) 58.6	Zirconium		

* See determination in preceding pages.

† Perhaps Te = 126.3.

Experiments at remarkably low Temperatures; Solidification of Alcohol and of Nitrogen.—The long-recognized distinction between condensible vapors and permanent gases was forever abolished in December, 1877, by the memorable experiments of Messrs. Cailletet and Raoul Pictet. These gentlemen, working independently and with different appliances, succeeded, it will be remembered, in liquefying oxygen, nitrogen, and even hydrogen, in glass tubes. Since that date S. Wroblewski

and K. Olszewski have taken up the study of the liquefaction of gases with great success. In 1882 Cailletet had recommended liquefied ethylene as a means of producing intense cold; this liquid at the normal pressure boils at -105°C . Having compressed oxygen in a tube, and cooled it by means of liquid ethylene to -105° , Cailletet observed, when some of the gas was allowed to escape, "a tumultuous ebullition which lasted for an appreciable time and resembled the projection of a liquid into the cooled portion of the tube," but the liquid and gas could not be separated. By means of a new apparatus, the Austrian chemists subjected comparatively large amounts of gas to a pressure of several hundred atmospheres, and thereby obtained some remarkably low temperatures; carbon disulphide and alcohol were solidified, and oxygen was easily and completely liquefied. By allowing the liquefied ethylene to boil in a vacuum a temperature of -136° was obtained, as determined by the hydrogen thermometer. Oxygen begins to liquefy at a pressure of 26.5 atmospheres and a temperature of -131.6° , and forms a colorless transparent liquid, very mobile, and yielding a sharp meniscus. Carbon disulphide freezes at about -116° ; alcohol becomes viscous like oil at about -129° , and solidifies to a white mass at -130.5° .

These results were communicated to the French Academy of Sciences early in the year 1883, and on the last day of the same year Wroblewski announced the following additional results.

Having succeeded in obtaining liquefied oxygen in large quantity he employed it as a refrigerating agent. When liquid oxygen is suddenly allowed to evaporate by release of the pressure it does not solidify like carbon dioxide, but it leaves a crystalline residue on the bottom of the apparatus. Whether this is crystallized oxygen or not, Wroblewski was unable to determine. In attempting to measure the temperature of oxygen in a state of ebullition he made use of a thermo-electric method which admits of the registration of all the sudden changes of temperature of the medium and is also very sensitive. Wroblewski gives the temperature of -186°C . "as the first approximation to the temperature produced by the sudden release from pressure of liquefied oxygen." By submitting nitrogen to this low temperature, the compressed gas allowed to expand a little solidifies and "falls like snow in crystals of remarkable size."

Experiments of this character demand great resources and are not devoid of danger. Wroblewski states that since the apparatus is partly constructed of glass great inconvenience is caused by the constant danger of serious explosions, and having experienced several accidents he and his assistants always work with masks before their faces. (*Comptes rendus*, xcvi, 1140 *et seq*. Also, abstracts in *Am. Chem. Journ.*, v, 146, and *Chem. News*, XLIX, 13.)

Radiant Matter Spectroscopy, a new Method of Spectrum Analysis.—William Crookes gave the Bakerian Lecture before the Royal Society

on May 31, 1883, under the above title, and presented a novel and remarkable extension of investigations into the phenomena of radiant matter with which his name is identified.

Many substances when struck by the molecular discharge from the negative pole in a highly exhausted tube emit phosphorescent light, some faintly and others with great intensity. On examining the emitted light in the spectroscope most bodies gave a faint continuous spectrum, and more rarely the spectrum of the phosphorescent light is discontinuous. Especial attention has been directed to the latter phenomenon. After a long and laborious search for an unknown substance which gave under the above conditions a bright citron-colored band or line, Crookes found it belonged to yttrium. In the course of his investigations he worked up 10 pounds of North Carolina zircons, 2 pounds of orangite and thorite and about 15 pounds of North Carolina samarskite, reviewing the characteristics of all the rare earths known to exist in these minerals and those awaiting confirmation. Crookes finally narrowed the elusive substance down to yttrium, the spectrum of which in a radiant matter tube is very beautiful, consisting of an intensely brilliant citron band and two bright green bands together with fainter lines not characteristic. The best results are obtained with the sulphate; pure yttria precipitated by ammonia does not phosphoresce in the slightest degree.

The extraordinary delicacy of this new test for yttrium is such that the element was detected when present in one-millionth part. Crookes found in pink coral 1 part of yttrium in 200 parts; strontianite contains 1 in 500; calcite 1 in 10,000; ox bone 1 in 10,000; an earthy meteorite 1 in 100,000; and tobacco ash 1 part in 1,000,000. The wide distribution of yttrium is notable. (*Chem. News*, XLVII, 261.)

Relation between the Composition and Absorption Spectra of Organic Bodies.—Gerhard Kriess and S. Economides have examined the absorption spectra of indigo and its methyl, ethyl, nitro and amido derivatives, with a view to determining the relation between chemical composition and absorption spectra. They conclude that the introduction of methyl, oxymethyl, ethyl, and bromine in the place of an atom of hydrogen moves the absorption bands to the less refrangible end of the spectrum, and the introduction of the nitro and amido groups has an opposite effect. The apparatus employed was the universal spectroscope, by A. Kriess of Hanover, having fine adjustments. (*Ber. d. chem. Ges.*, XVI, 2051.)

INORGANIC.

Boron.—The substances obtained by the action of aluminium on boric acid at a very high temperature have been variously described by chemists; Deville and Wöhler obtained yellowish or reddish regular octahedra, containing variable proportions of carbon and of aluminium, together with lustrous black scales or plates containing 2.4 per cent. carbon. On the other hand, Hampe assigned to the black crystal-

line plates the formula Al B_6 and to the yellow octahedra the formula $\text{C}_2\text{Al}_2\text{B}_{24}$. These discrepancies have led to an examination of the subject by A. Joly, who states that at the elevated temperature used by Deville and Wöhler only very small quantities of the large black plates were obtained, but at a lower temperature, with small quantities of material, smaller black crystals united to the yellow ones are formed. It is this substance that Deville and Wöhler probably analyzed, while Hampe reduced boric acid in clay crucibles at a much lower temperature and obtained large black crystals containing but little carbon. Joly also finds that the yellow crystals AlB_6 dissolve readily in boiling nitric acid without a residue, but the brown or black crystals obtained at a high temperature leave a carbonaceous residue when treated with the same oxidizing agent. The products of the reduction of boric acid by aluminium therefore embrace:

- (1) AlB_6 , yellow hexagonal plates.
- (2) AlB_6 , large black crystalline scales.
- (3) Yellow cubical crystals containing Al and C.
- (4) Several compounds of carbon and boron not further characterized. (*Comptes rendus*, XCVII, 456.)

Hydrated Carbon Disulphide.—All who have worked with carbon disulphide are familiar with the peculiar cauliflower-like growth of a snow-white substance which forms when the volatile liquid is filtered or otherwise exposed to rapid evaporation. Berthelot, Wartha, Ballo, and others, have studied this substance, and the latter has recorded some experiments to prove that the white excrescence is a hydrate and not solid carbon disulphide. Prof. F. P. Venable, of the University of North Carolina, has studied anew this body and obtained evidence that the amount of moisture in the air has a decided effect upon the ease and rapidity of its production. No fixed law, however, could be deduced. The following experiment is conclusive and confirms Ballo's results: An open-necked bell-jar, ground, greased, and tightly fitting to a ground-glass plate was provided with a large rubber stopper pierced with two holes. Through one of these openings a calcium chloride tube 250 mm. long was inserted, and through the other a glass tube with a glass rod working tightly in it and rendered air tight by rubber tubing. Inside the bell-jar was placed a watch glass containing purified carbon disulphide supported above a vessel of fresh concentrated sulphuric acid. A small strip of previously dried filter paper was attached to the end of the glass rod within the bell-jar, and when this was lowered it dipped into the volatile liquid; the liquid rose rapidly in the pores of the paper, but even after some minutes no sign of a solid incrustation was visible. When, however, the sulphuric acid was replaced by water the solid began to form immediately after the lowering of the paper. By drawing air through the jar until it was filled with aqueous vapor the solid hydrate suddenly and completely melted away. During the evaporation of the carbon disulphide in an

open shallow dish the liquid reached a temperature of -6°C . By forcing air over it the thermometer fell to -19.5°C . (*Am. Chem. Journ.*, v, 15.)

Blue Chloride of Sodium.—This mineralogical curiosity occurs in small quantity in the salt mines of Stassfurt and the cause of the blue coloration has been studied by B. Wittjen and H. Precht. As already noticed by F. Bischof, the blue salt imparts no color to its aqueous solution; and the authors of this paper find that no coloring matter can be extracted by ether or by carbon disulphide. S. W. Johnson has suggested that the blue color is due to sodium subchloride, but these authors find that the color is not at all affected by heating the salt at 100°C . in chlorine gas. They therefore conclude that the blue color is an optical phenomenon. Pulverization and heating to 280°C . destroys the color, probably owing to the liberation of confined gases. (*Ber. d. chem. Ges.*, xvi, 1454.)

The *Fluorine compounds of Uranium* were made the subject of investigation in 1866 by H. Carrington Bolton. Ditte (*Comptes rendus*, 91) afterwards prepared the same bodies and gave analytical data differing widely from those of Bolton. Arthur Smithells has now gone over the same ground and confirms the results previously obtained by Bolton, and shows that the compounds claimed by Ditte have no existence. (*J. Chem. Soc.*, March, 1883.)

Nitrogen Selenide has been prepared by M. Verneuil, by acting on a mixture of selenium perchloride and carbon dichloride with dry ammonia gas. Its composition is Se_2N , and it forms a light orange amorphous powder, insoluble in water, ether, and alcohol, slightly soluble in benzene and carbon disulphide. When dry it detonates if struck with a hard body, and explodes if heated to 230°C . (*Bull. soc. chim.*, xxxviii, 548.)

Occurrence of Thallium in Sylvite and Carnallite.—Julian Schraumm gives the following analysis of sylvite from Kalusz:

Potassium chloride.....	99.250
Sodium chloride	0.594
Calcium chloride	0.012
Calcium sulphate	0.143
Thallium chloride	traces.
	99.999

The author found thallium in carnallite and in kainite; in the former it is associated with rubidium, but the latter contains neither rubidium nor cesium. He thinks this association gives additional grounds for classifying thallium with the alkali-metals. Sodium, lithium and cesium occur together on one hand, and potassium, rubidium, and thallium on the other. (*Liebig's Annalen*, CCXIX, 374.)

Researches on the Compounds of Gold.—P. Schottländer has published an extended research on gold and its salts, in which he describes several new bodies and examines with care reactions already known. Auro-potassium bromide forms a very stable salt, neither deliquescent nor efflorescent and obtained in large crystals. The action of manganous acetate on neutral gold chloride yields a mixture of metallic gold and hydrated oxide of manganese of varied composition. Hydrated gold monoxide $\text{Au}^{11}_2\text{O}_2(\text{OH})_2$ forms a light crystalline powder of a pure black color. Hydrochloric acid decomposes it with formation of the metal, trioxide and water. Nitrate of goldtrioxinitrate, aurylnitrate, acid aurylsulphate and its potassium compound and gold monoxysulphate $\text{Au}^{11}\text{SO}_4$ are further described in this paper. Schottländer regards gold as divalent. (Liebig's *Annalen*, CCXVIII, 312.)

Manufacture of Aluminium.—Secular papers and scientific journals contain notices of improved methods in the industrial preparation of aluminium, some of which were patented in the year 1882, and great claims are advanced as respects the economy of the processes. Aluminium, it will be remembered, was first obtained in its metallic state by Friedrich Wöhler in 1826, who decomposed the chloride by sodium, and although (with one exception) aluminium is the most abundant metal known, thirty years elapsed before its industrial preparation was successfully accomplished. This was done by Henri Sainte Claire Deville, who improved greatly the preparation of sodium, the most expensive ingredient used. Still the metal has sold at the relatively high price of \$20 per pound, and its physical properties are such that its production at cheaper rates is most desirable. James Webster, an English chemist and metallurgist, has devised the following method for the preparation of alumina for the purpose of manufacturing the metal: Three parts of alum are mixed with one part of coal pitch, and the mixture heated to 200° to 260° for about three hours. The mass is cooled, broken into pieces, and hydrochloric acid of 20 to 25 per cent. is poured over them, giving rise to the evolution of sulphuretted hydrogen. When this gas ceases to come off about 5 per cent. of charcoal powder or lamp-black is added and enough water to make a thick mass. This mass is thoroughly broken up and mixed in a mill, and then worked into balls weighing about one-half kilogram each. These balls are perforated to facilitate drying, and dried first in a chamber heated to 40° and then in a furnace at 95° to 150° . The balls are then placed in retorts and heated to low redness for about three hours, while a mixture of two parts of water vapor and one of air is passed through, so that sulphur and charcoal are converted into sulphur dioxide and carbon dioxide and thus escape. The dry residue, consisting of aluminium, oxide and potassium sulphate, is removed from the retorts, cooled, ground to powder in a mill, and treated with about seven times its weight of water, and after boiling by means of steam, the solution containing potassium sulphate is run off and evaporated to dryness. The residue, consisting

of aluminium oxide, is washed and dried. At the *Aluminium Crown Metal Works*, in Hollywood, under the direction of Mr. Webster, another method is said to be employed. The mineral beauxite, an aluminium-ferric hydrate, is ignited with sodium carbonate, and the sodium aluminate formed is decomposed with carbonic anhydride, yielding pure alumina; this is then heated with charcoal in a current of chlorine, forming a double chloride of sodium and aluminium, which is finally decomposed by sodium, furnishing aluminium. It is said that a ton of the metal costs by this process only \$500, whereas it formerly cost \$5,000. At Webster's works, it is said that the output of metal amounts to 20 (!) tons per week, a manifest exaggeration.

J. Norris, of Uddington, near Glasgow, has obtained a patent for manufacturing aluminium by treating an intimate mixture of alumina and charcoal with carbonic anhydride at a low red heat, a reaction which is regarded as doubtful by many chemists. Morris claims that the carbonic anhydride is reduced to carbon monoxide by the charcoal, and that in turn reduces the alumina. The metal is obtained by this process as a porous, spongy mass which is melted and poured into molds.

At Salindres, France, about 2,400 kilogrammes of aluminium are manufactured annually. The process is the old one of decomposing the double chloride of aluminium and sodium by metallic sodium, some cryolite being added as a flux.

The chief value of aluminium at present is in tempering or giving strength and a surface or body to alloys, bronzes, or metals so they will not corrode. In the bronze $\frac{1}{1700}$ part of aluminium tends to soften the brittle and hard nature of the baser metal. The tensile strength of aluminium bronze is great; it bears a strain of 42 tons to the square inch, or 12 tons more than the best Bessemer steel. It is said to be unequalled for pianos and telegraph wires. Dr. Gegring, of Land street, is reported to have invented an inexpensive process for coating ordinary iron with aluminium, and the coating can be given any color desired. (Dingler's *polytechnisches Journal*, and other sources.)

Present Condition of the Soda Industry in Europe.—Mr. Walter Weldon read an important paper on the above subject before the London section of the Society of Chemical Industry, on January 8, 1883. He stated that in recent years manufacturers of soda by the Leblanc process had failed to reap satisfactory profits and in some cases had met with financial ruin. Of twenty-five alkali works which were in operation in the neighborhood of Newcastle-on-Tyne a very few years ago only thirteen are in operation now, and of the other twelve, not fewer than eight have been actually dismantled, in utter despair of its ever again being possible to manufacture soda in them by the Leblanc process except at an absolute loss. In Belgium the industry has entirely ceased; in France, Germany, and Austria the industry still exists, being protected by impost duties. Aided by manufacturers in all parts of the world Mr. Weldon has

compiled the following table of the present soda production in various countries :

Present soda production of the world.

Countries.	Leblanc soda.	Ammonia soda.	Totals.	Ammonia soda per cent. of total soda.
Great Britain.....	380,000	52,000	432,000	12.0
France.....	70,000	57,125	127,125	44.9
Germany.....	56,500	44,000	100,500	43.8
Austria.....	39,000	1,000	40,000	2.5
Belgium.....	.....	8,000	8,000	100.0
United States.....	.....	1,100	1,100	100.0
Tons.....	545,500	163,225	708,725	23.0

From this it is evident that the total quantity of soda now being manufactured annually is nearly 709,000 tons, of which more than 163,000 tons are made by the ammonia process.

Although the ammonia process was first proposed by Dyer & Hemming more than forty-seven years ago, it is less than seventeen years since it has been carried on industrially. In 1866 Ernest Solvay, of Brussels, began to produce soda by the ammonia process at his works near Charleroi; in 1866-'67 he manufactured 179 tons; this increased to 11,580 tons in 1876-'77, and 53,400 tons in 1881-'82. Mr. Weldon estimates that about 40 per cent. of the total soda now made on the continent is produced by the ammonia process. In England, also, the competition of the ammonia process has attained a magnitude which is alarming the makers of Leblanc soda.

Another circumstance is injuriously affecting the Leblanc system, viz, the loss of profits on the by-products. Originally, soda was the only commercial product of the process, the hydrochloric acid being turned to no account. In time a demand grew up for chlorine, and the hydrochloric acid began to be utilized profitably; then the soda ceased to be profitable, and became a by-product in the manufacture of chlorine; next, this source of profit failed and recourse was had to the "burnt ore" or "pyrites cinders" obtained as a secondary product by roasting pyrites for sulphuric acid, and which is treated for copper, silver, and to some extent for gold. The Rio Tinto Company, of Spain, owning enormous deposits of pyrites, intend establishing in France and elsewhere works for manufacturing Leblanc soda, and expect to derive their profits neither from the soda nor from the chlorine, but from the copper and the residual oxide of iron.

The extension of the ammonia process of manufacturing soda has led to devising plans for obtaining ammonia itself more cheaply, and it is now collected from coke ovens in France and in England, and from blast furnaces in Scotland. From the latter source alone Mr. Weldon

estimates the amount of ammonium sulphate produced at 20,000 tons per annum.

To maintain the Leblanc industry in England, Mr. Weldon thinks the manufacturers must have cheaper pyrites, and must perfect methods for the recovery of sulphur from the alkali waste. He regards favorably the Schaffner and Helbig process for sulphur recovery, which consists of two operations indicated by the following equations:

First operation.



Second operation.



In closing his interesting paper, of which we have given but a brief summary, Mr. Weldon states that the immediate future of the English Leblanc soda industry is somewhat gloomy, but suggests the motto *nil desperandum*. (*Chem. News*, XLVII, 67 *et seq.*)

Phosphides of Platinum.—Prof. F. W. Clarke and Mr. O. T. Joslin have examined the bodies resulting from the fusion of platinum and phosphorus, a process suggested by the discovery of Mr. Holland, recorded in our previous report. Professor Clarke finds proof of the existence of three simple phosphides, PtP_2 , PtP , and Pt_2P , and of a double phosphide, Pt_3P_5 . The monophosphide by virtue of its insolubility in aqua regia, is the most noteworthy. The compound Pt_2P is malleable and is analogous to Pt_3P previously described, and called in the patent of Mr. Holland “fused iridium.” The compound PtP_2 is probably identical with the phosphide described by Schrötter and obtained by heating the finely divided metal in phosphorus vapor. (*Am. Chem. Jour.*, v, 231.)

Researches on the Complex Inorganic Acids.—Dr. Wolcott Gibbs, in two additional papers, continues his investigations in the remarkable field mentioned in our report for 1882. He describes the preparation and properties, and discusses the structural formula of hypophospho-molybdates, hypophospho-tungstates, phosphoroso-molybdates, vanadio-molybdates, vanadio-tungstates, phospho-vanadio-molybdates, vanadio-vanadico-molybdates, vanadio-vanadico-tungstates, phospho-vanadio-vanadico-tungstates.

It is impossible in the brief space at our command to give an adequate idea of these remarkable researches. The evident beauty of many of the well crystallizing complex salts, the exceedingly difficult problems in analytical chemistry which are involved, and the admirable theoretical discussions conjoined, make these papers masterpieces in the science. (*Am. Chem. J.*, v, 361 and 391.)

Manufacture of Potash Alum from Feldspar.—In 1882 Mr. John Spiller published an article proposing to manufacture potash alum by treating

feldspar with sulphuric acid and a fluoride, the latter being either fluor-spar or cryolite. Both these minerals can be had very cheaply, but Mr. Henry Pemberton, jr., undertakes to show that the difficulties of the process are such as to leave little or no margin for profit. The weak point in the process is the quantity of acid required, and in the production of three tons of bulky, insoluble, comparatively useless calcium sulphate for every ton of alum made. Cryolite is shown to be too expensive, and moreover yields the wrong alkali, soda in place of potash. And if the necessary potash were added, enormous quantities of Glauber's-salt would be left upon the manufacturer's hands. (*Journ. Frankl. Inst.*, 1883.)

Analyses of the Geyser Waters and Deposits of the Yellowstone National Park.

Dr. Henry Leffmann has published analyses of the waters of several of the Yellowstone Geysers and of the incrustations forming in their vicinity. From these we select the following:

I.—*Pearl Geyser.*

	Grains in imp. gallon.
Calcium sulphate	1.40
Sodium sulphate	1.89
Sodium chloride	61.39
Silica	7.84
	72.52

At the bottom of the bottle containing this water impure gelatinous silica was found yielding after drying over strong sulphuric acid:

	Per cent.
Water	4.9
Silica	79.1
Alumina	traces
Ferric oxide	traces
Calcium oxide	traces

II.—*Opal Spring.*

The water of this spring is opalescent and on evaporation gelatinizes before becoming dry:

	Grains in imp. gallon.
Sodium chloride	72.18
Calcium sulphate	3.22
Calcium chloride	4.06
Silica	53.76
	143.22

III.—*Water of Mammoth Hot Springs.*

	Grains in imp. gallon.
Sodium sulphate.....	34.44
Sodium chloride.....	18.90
Calcium carbonate.....	17.92
Magnesium carbonate.....	8.68
Silica.....	3.36
	83.30

IV.—*Deposit from Mammoth Hot Springs.*

Calcium carbonate.....	96.80
Magnesium carbonate.....	1.36
Alumina and iron.....	0.45
Silica.....	0.25
Water.....	0.50
	99.36

(Am. J. Sci., CXXV, 104 and 351.)

Decomposition of Minerals by Citric Acid.

H. Carrington Bolton has continued his investigations as to the action of organic acids on minerals, and publishes the following results. The acid employed was citric acid, which, as the author has shown, has a power of decomposing minerals little less than that of hydrochloric acid; the effect of prolonged action at ordinary temperatures was especially considered. Of the sulphides, chalcocite showed signs of decomposition at the end of ten days, and after several months a partial solution of a green color was obtained; pyrite was attacked in eight days, and a month later a solution of a reddish yellow color was obtained; chalcopyrite acted similarly; one gram lost 11 per cent. after fourteen months' contact with the citric acid solution. Of the oxides magnetite and limonite were strongly attacked in eight days, hematite yielding more slowly. Of the silicates datolite was the most quickly decomposed, yielding gelatinous silica after twenty-four hours; hornblende, pyroxene, almandite, epidote, and serpentine were decidedly decomposed in eight days, and after fourteen months the last named yielded a dry, gelatinous mass. The feldspars are unequally attacked under like conditions; labradorite yielded most easily. Muscovite and biotite yielded very slowly, the latter showing signs of decomposition the sooner, minute scales and slimy silica separating after two years' subjection to the acid solution.

Dr. Bolton gives the following :

Table showing approximate relative disintegration of rock-forming (and associated) minerals by citric acid in solution.

Quickly decomposed.	Slowly decomposed.	Very slowly decomposed.	Not decomposed.
Carbonates. Phosphates. Prochlorite. Chrysolite. Nephelite.	Serpentine. Pyroxene. Hornblende. Labradorite. Garnet. Epidote. Vesuvianite. Pyrite. Limonite. Magnetite. Gypsum. (?)	Orthoclase. Oligoclase. Albite. (?) Biotite. Muscovite. Tourmaline. Staurolite. Hematite.	Quartz. Corundum. Spinel. Beryl. Barite. Talc. (?) Kyanite.

(*Proceedings Am. Assoc. Adv. Science*, XXXI, 271.)

New Explosives.—Pyronome is the name given by M. Sandoy to a new explosive mixture consisting of 69 parts saltpeter, 9 of sulphur, 10 of charcoal, 8 of metallic antimony, 5 of potassium chlorate, 4 of rye flour, and a few centigrams of potassium chromate. These are to be mixed in an equal volume of boiling water, and the mass evaporated down to a paste, dried and powdered as wanted. This mixture is said to be cheaper than dynamite, but its manufacture and use must be attended with considerable danger.

S. H. Hinde proposes a new explosive mixture composed of 64 parts of nitro-glycerine, 12 of ammonium citrate, 0.25 of ethyl palmitate, 0.25 of calcium carbonate, 23 of coal, and 0.50 of sodium carbonate. The special advantages of this complex mixture do not appear.

A new explosive has just been patented in England by Dr. C. W. Siemens. The compound is a mixture of saltpeter, chlorate of potash, and a solid hydrocarbon, and is suitable both for mining purposes and fire-arms, while, if ignited in the open air, the combustion takes place slowly and imperfectly, and, therefore, without danger. The new compound, which has about the same density as ordinary gunpowder, and is very hard, possesses with equal volume more than double the explosive force of the latter. The intensity of explosion can be regulated at will by varying the proportions of the ingredients and the size of the granules. (*Munroe's Notes on the Literature of Explosives.*)

Use of Limed Coal in Gas-making.—Prof. J. Alfred Wanklyn read a paper on the above subject before the British Association for the Advancement of Science at the Southport meeting in August, 1883.

As the gas manufacture is usually carried on, only a small part of the nitrogen contained in the coal is recovered in the form of ammonia;

whereas the coal might furnish 25 to 50 pounds of ammonia per ton of coal, only 5 or 6 pounds are actually obtained. By mixing a little lime with the coal before introducing it into the retort, the yield of ammonia is greatly increased, and at the same time the gas issuing loses its fetid odor. The invention is patented, and is known as Cooper's liming process.

At the Beckton gas-works, where a series of experiments were carried on, the addition of lime produced a gain of 36 per cent. of ammonia. Besides this, there is a gain in tar and a diminution in the sulphuretted hydrogen and carbon disulphide. So marked is the latter feature that the lime purifier proves to be superfluous where the process is used, and gas-works, being no longer offensive, cease to be a public nuisance. (*Chem. News*, XLVIII, 174.)

ORGANIC.

New Substances from Plants.—Jamaica dogwood (*Piscidia erythrina*) has been examined by Prof. Edward Hart, of Lafayette College, who obtained therefrom the active principle, *piscidia*, $C_{29}H_{24}O_8$. This body is insoluble in water, but crystallizes from alcohol in small colorless four or six sided prisms, which have a melting point of 192° C. It is easily soluble in benzene and in chloroform. Its physiological effects are that of a direct sedative, narcotic but refreshing. (*Am. Chem. Journ.*, v, 39.)

Algin is the name given by Edward C. C. Stanford to a new substance obtained from some of the commoner species of marine algæ, and which possess valuable properties as a gelatizer. It has characteristic reactions distinguishing it from gelatin, from starch, from dextrin, pectin, gum arabic, and other gummy bodies. Dilute mineral acids generally coagulate it when in solution. Mr. Stanford thinks it can be used in the soluble form as a stiffener of fabrics; although not so rigid as starch, it is tougher, more elastic, and more transparent. It may also have some value as a food on account of its nitrogenous character. Its agglutinating power enables one to convert non-coherent bodies, such as silica, lime, magnesia, alumina, chalk, graphite, and charcoal, into solid hard blocks. A new "carbon cement" for covering steam-boilers consists of 97 per cent. charcoal and 3 per cent. algin. In its insoluble form algin resembles horn, and may be used as a substitute for it. Algin is an excellent non-conductor of electricity, and can be used also in emulsifying oils and fining wines and spirits. (*Chem. News*, XLVII, 254.)

A new acid has been obtained by Von Lippmann from the juice of the beet root. The incrustations formed on the pans in which beet juice is evaporated contains, besides citric, aconitic, tricarballic, and malonic acids, a new acid which appears to be identical with the oxycitric described by Pawolleck. The new acid forms needle shaped crystals, soluble in water, alcohol, and ether, having the formula $C_6H_5O_8$. It is tribasic, its barium salt having the formula $(C_6H_5O_8)_2 Ba_2 \cdot 5 H_2O$. (*Ber. d. chem. Ges.*, XVI, 1078.)

Saponin was discovered in 1809 by Schrader in the root of *Saponaria rubra*. Stütz prepares it from the bark of *Quillaja saponaria* as follows: 10 kilograms are extracted with water, the evaporated liquid is dried, pulverized and extracted with hot alcohol, which on cooling yields flocks of saponin; these are purified by re-solution in hot alcohol. In this way 10 kilograms of bark yielded 200 grams of saponin. It is a white, amorphous powder, neutral and tasteless. It is soluble in water in all proportions, and even when dilute the solutions froth like a soap solution. It has the composition expressed in the formula $C_{19}H_{20}O_{16}$, but contains also 2.4 per cent. ash, consisting of the carbonates of magnesium, calcium, and potassium. Experiments lead the author to conclude that the constitution is expressed in the formula $C_{19}H_{25}(OH)_5O_3$. (Liebig's *Annalen*, CCXVIII, 231.)

A New Source of Mannite.—L. Lindet has found this sugar quite abundant in the pineapple of Brazil, amounting, he claims, to 1 per cent. of the fresh fruit. The mannite is extracted from the fermented pulp by neutralization with sodium carbonate and evaporation to the consistence of molasses. On cooling small needle-shaped crystals, having a slightly sweet taste, are obtained; purified by solution in boiling alcohol they give the true characters of mannite. He intends to prosecute the study with a view to ascertaining whether the mannite was formed during the fermentation or whether it exists already formed in the fruit itself. (*Bull. soc. chem.*, XL, 65.)

Saccharone and Saccharine.—By the action of calcium hydrate on dextrose and on levulose Péligot obtained in 1880 a body having great stability and crystallizing with facility, which he called saccharine. Heinrich Kiliani, by acting on this body with concentrated nitric acid, has obtained a new substance, which he names saccharone, and which is both a lactone and a monobasic acid. Consequently both saccharone potassium C_6H_7OK and saccharonate of potassium $C_6H_5O_7K_2$ are obtained when saccharone is treated with potassium, the latter at a boiling temperature. By the action of hydriodic acid on saccharone, saccharinic acid, a dibasic acid is obtained, having the formula $C_6H_{12}O_6$. (Liebig's *Annalen*, CCXVIII, 361.)

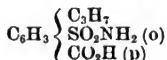
Borneol from Camphor.—Professors C. Loring Jackson and A. E. Menke recommend the following process for preparing borneol from camphor on account of its simplicity, rapidity, and economy. The camphor is dissolved in about ten times its weight of common alcohol, and an excess of sodium is added in pieces of somewhat less than a gram at a time. By working with quantities not over ten grams the action can be carried on in an open flask without cooling. As soon as all the sodium has disappeared, part of the alcohol is distilled off and water added, which precipitates crude borneol. This is freed from sodium hydroxide by washing with water, and crystallized from hot alcohol.

Borneol melts at 197° ; 10 grams of camphor yield 9.5 grams of borneol being 94 per cent. of the theory. (*Am. Chem. Journ.*, v, 270.)

Researches on Atropine.—In 1863, Kraut decomposed atropine by a boiling barium hydrate solution into atropic acid $C_8H_8O_2$, and tropine $C_8H_{17}NO_2$; the formula for the latter base was corrected by Lossen, who found $C_8H_{15}NO$, and showed that atropic acid was only a secondary product of the decomposition, the primary being tropic acid $C_8H_{10}O_2$. Ladenburg in late researches has affected the synthesis of atropine by the dehydration of tropate of tropine. The best results were obtained by the action of dilute hydrochloric acid. The identity of the artificial atropine with that extracted from atropa belladonna was fully established by chemical and physiological experiments. Tropate of tropine exerts no action whatever on the eye, even in a 10 per cent. solution. (Liebig's *Annalen*, CCXVII, 74.)

The Oxidation of Substitution Products of the Aromatic Hydrocarbons.—Dr. Ira Remsen is pursuing his investigations grouped under the above title, and publishes two additional contributions on the oxidation of betacymenesulphamide and of paradipropylbenzenesulphamide in which he has been assisted by Mr. W. C. Day and Dr. E. H. Keiser, respectively.

By treating betacymenesulphamide with potassium pyrochromate and sulphuric acid a body was obtained which proved to be sulphamine-parapropylbenzoic acid having the formula—

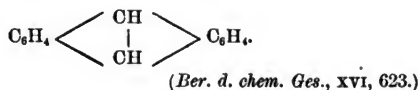


Under similar treatment paradipropylbenzenesulphamide yielded as a principal product alphasulphaminepropylbenzoic acid, the formation of which under the conditions given proves that the sulphamide group exerts a partial protective action upon one of the propyl groups. The protection, however, is not perfect, because sulpho-terephthalic acid is formed at the same time. These results are in perfect harmony with the views advanced some time ago by Dr. Remsen as to the law of protection. (*Am. Chem. Journ.*, v, p. 149.)

Synthesis of Salicin.—Prof. Arthur Michael, of Tufts College, has the honor of accomplishing the first synthesis of a glucoside occurring in nature. Having obtained helicin synthetically by the action of sodium salicylaldehyde on acetochlorhydrase, he submitted the helicin to the action of sodium amalgam, as suggested by Lisenko, and obtained a body the properties and composition of which agree perfectly with natural salicin. (*Am. Chem. Journ.*, v, p. 171.)

A new Synthesis of Anthracene.—With the expectation of obtaining an isomeric tetraphenylethane, Anchütz and Eltzbacker examined the action of aluminium chloride upon a benzene solution of acetylene tetra-

bromide. The resulting hydrocarbon was easily isolated and proved to be anthracene. This synthesis establishes the fact that the middle carbon atoms in anthracene are directly united, a supposition generally held but not previously determined by experiment. The formula of anthracene is accordingly represented thus :



Pyridine and Quinoline Bases.—The close connection which has been established between several important alkaloids and the derivatives of pyridine and quinoline is being confirmed by numerous researches. All the evidence accumulated thus far is in harmony with the view that many of the important alkaloids are derivatives of pyridine, a constituent of bone-oil and of coal-tar, which, moreover, has been obtained by the dry distillation of nicotine. The relation between these alkaloids and pyridine is somewhat analogous to that between the aromatic compounds and benzene. According to Körner pyridine is benzene in which one of the six CH groups is replaced by N, and this view has recently found additional support.

The investigations of Königs, Skraup, and others go to establish a close connection between quinoline (and its homologues lepidine, dispoline, and tetrahiroline) and such alkaloids as quinine, cinchonine, and their isomers. (E. H. K. in *Am. Chem. Journ.*, v, 60.)

Constituents of the Petroleum of Galicia.—According to Lachowicz, the petroleum of Galicia contains a large number of hydrocarbons of the marsh-gas series, isopentane, normal pentane, hexane, both normal and secondary, and heptane, together with several of the aromatic series, benzene (benzol) toluol, isoxylol mesitylene, and the so-called Vreden's hydrocarbons. Members of the ethylene series are entirely wanting. (Liebig's *Annalen*, ccxx, 168.)

Products of the Dry Distillation of Wood at low Temperatures.—Prof. C. F. Mabery has examined the more volatile products of the dry distillation of wood in the manufacture of acetic acid. The greater part of the product consists of methyl alcohol and methyl acetate; besides these are found acetic aldehyde, acetic acid, acetone, acetal, dimethyl-acetal, methylethylketone, and allyl alcohol, together with traces of the higher ketones. A new constituent is methyl formiate. The higher boiling oils contained furfural, and by the action of alkalies upon it a small quantity of pyrozanthin. The proportion of acetone was small. (*Am. Chem. Journ.*, v, 256.)

The Constituents of Ozokerite.—Ozokerite from the island Tscheleken, in the Caspian Sea, has been examined by F. Beilstein and E. Wiegand.

The raw material formed a brownish-black, sticky mass, almost wholly soluble in boiling benzene. On adding alcohol to the filtered solution most of the paraffine precipitates and the oils remain in solution. By treating the powdered ozokerite with ether nearly all the oily matters and coloring matters are removed from the paraffine, and this may be further purified by solution in benzene, boiling with animal charcoal and precipitation by alcohol. By repeating this process, shining white crystals, having a definite melting point, were obtained, which the authors name Lekene, from the island above referred to. Lekene has the following properties: Melting point, 79° ; sp. gr., 0.93917. Soluble in 124.3 parts of benzene at 15° , 1334.8 parts of chloroform at 16° , 9534 parts of alcohol at 16° , and 15257 parts of absolute acetic ether at $16\frac{1}{2}^{\circ}$ C. It distills unaltered in vacuo, and hence may be obtained by this process on a commercial scale. Nitric acid diluted with two volumes of water scarcely attacks lekene at all; fuming sulphuric acid converts it quickly into a black, pulverulent mass. The analysis made gave following figures: C=85.23 per cent., H=14.72 per cent. It does not appear whether lekene belongs to the series $C_n H_{2n}$, or $C_n H_{2n+2}$. The oil extracted by ether from the ozokerite was purified by distillation in vacuo and gave 86.13 per cent. C. and 13.70 per cent. H. Its sp. gr.=0.8450 at 18.5° . (*Ber. d. chem. Ges.*, XVI, 1547).

Researches into the Nature of Resins.—Prof. Arthur Michael has instituted an investigation into the action of aldehydes on phenols, and arrives at the following conclusions: (1) Mixtures of aromatic aldehydes and phenols are converted by mere traces of acids, more or less rapidly, according to the acids used, into white resins; (2) the resorcin-benzaldehyde resin is converted by the further action of dilute acids into two crystalline compounds, one of which is isomeric with the resin when the latter is dried at 100° C.; (3) fixed alkalies and potassium carbonate convert a mixture of resorcin and benzoic aldehyde into a resin; (4) the properties of the crystalline compound $C_{26}H_{20}O_4$ resemble those of the so-called crystallizable resins. From its alkaline solution it is precipitated by acids in the form of a resin, which separates in form of the original crystals from the alcoholic solution; (5) the above results make it extremely probable that the formation of at least some of the resins in the vegetable world is due to aldehydes and phenols coming in contact with the contents of the cells, as both of these classes of compounds are undoubtedly among the products formed in plant-life. (*Am. Chem. Journ.*, v, 338.)

Coniferin, the source of vanillin, has been found by Edmund O. von Lippmann to exist in the woody fiber of the sugar-beet. It is believed that the coniferin does not exist to any great amount ready formed in the woody fiber, but that it is produced by the decomposition of lignin in the process of extraction. Whether or not the sugar-beet will ever become a commercial source of vanillin has not been determined. (*Ber. d. chem. Ges.*, XVI, 44.)

NOTES.

A simple and convenient apparatus for rapid gas analysis has been devised and described by Arthur H. Elliott. By its aid a complete gas analysis can be made in less than one hour. For details and figure of the apparatus we refer to *Annals of the New York Academy of Sciences*, Vol. II, No. 12, 1883.

Carbon monoxide is conveniently prepared, according to E. Noack, by passing carbon dioxide over zinc dust heated in a glass tube below a red heat. In one hour 13 liters of CO_2 yielded 11 liters of CO.

Dr. W. Spring continues his researches on the formation of chemical compounds by great pressure. He has prepared, under pressure of 6,500 atmospheres, compounds of arsenic with zinc, lead, copper, tin, and silver direct from mixtures of the constituents. Also many metallic sulphides in like manner.

The composition of bleaching-powder has again been investigated by Lunge and Naef, who find that calcium chloride is decomposed at ordinary temperatures by hypochlorous acid, with the production of CaOCl_2 and Cl_2 . These chemists hold to the formula $\text{Cl} - \text{Ca} - \text{OCl}$, first proposed by Odling, as the most correct. (*Ber. d. chem. Ges.*, XVI, 840.)

Water is decomposed by both sulphur and arsenic, according to C. Z. Cross and A. F. Higgin, yielding both the oxygen and hydrogen compounds of the elements.

Dr. J. Lawrence Smith gives in the *American Chemical Journal*, v, p. 44, details of his method of decomposing and analyzing samarskite. The powdered and dried mineral is decomposed by fluorhydric acid and the insoluble portion treated with concentrated sulphuric acid and the contained earths converted into oxalates, which are then submitted to careful analysis.

Samarium, discovered in 1878 in samarskite by Lecoq de Boisbaudran, has been carefully studied by P. T. Cleve, of Upsala. He obtained the pure oxide, Sm_2O_3 and several salts, including the chloride, $\text{SmCl}_3 \cdot 6\text{H}_2\text{O}$, chloroplatinate, nitrate, $\text{Sm}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$, acetate, oxalate, and sulphate, $\text{Sm}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O}$. The salts in general agree closely in composition with the didymium salts, but are distinguished by a peculiar spectrum composed of several bands, four in the blue part being characteristic. (*J. Chem. Soc.*, 1883, 362.)

The emission spectra of scandium, ytterbium, and erbium have been examined by Th. Thalén. Scandium presents a notable spectrum, having many lines of medium intensity in the orange and the indigo, and very fine brilliant lines, forming several groups, in the yellow, green, and blue portions.

Pure nickel, capable of being wrought, rolled, and hammered, is now made by Mr. Joseph Wharton at Camden. A small quantity of magnesium added to metal greatly aids in the refining and improves its quality. Mermet recommends the use of nickel crucibles in place of silver in chemical manipulations, being much cheaper and less easily fused.

Notes on the Literature of Explosives.—Under this title Prof. Charles E. Munroe, of the United States Naval Academy, is publishing a series of papers giving a compendium of discoveries in the field mentioned. The articles appear in the Proceedings United States Naval Institute, Nos. 20, 21, 22, 24, and 27 *et seq.*

A white modification of phosphorus has been described by Drs. Ira Remsen and E. H. Keiser. It is obtained by distilling ordinary phosphorus in hydrogen and collecting the element in ice-cold water. This white phosphorus is light and plastic, is soluble in carbon disulphide, and melts at the same point as ordinary phosphorus. It bears the same relation to ordinary phosphorus as "flowers of sulphur" to "roll brimstone."

The conduct of moist phosphorus and air towards carbon monoxide has been again most carefully examined by Ira Remsen, assisted by E. H. Keiser, and, contrary to the views of Leeds, negative results are reported. The small amount of carbon dioxide obtained by Leeds is ascribed to oxidation of the carbon in the phosphorus, the presence of which was not, however, demonstrated by the author. (*Am. Chem. J.*, v, 424.)

According to the latest returns published by the Italian Government, the average annual production of sulphur in Sicily and Italy during the five years 1875–1879, inclusive, was 282,000 tons, of which 216,000 tons were exported. Delivered at Marseilles the sulphur sells at about \$25 per ton. (*Chem. News*, XLVII, 88.)

Cadmium iodide has been studied by Prof. F. W. Clarke, who obtained evidence of the existence of two allotropic varieties, differing in specific gravity by about a unit. The higher or normal salt is white, and undergoes no perceptible change when heated below 250°; the lower salt is brownish, and loses weight at 40°.

The use of mercury thermometers, and especially the determination of melting point and boiling point, is the subject of an exhaustive research by Prof. J. M. Crafts, who points out that the defects in the processes of graduating these instruments, as usually conducted, can be remedied by means easily within the reach of a careful mechanic.

Thiophene is a new substance, C_4H_4S , discovered by Victor Meyer in benzene (benzol) from coal tar, and which is marked by its containing sulphur in its composition. It forms a light, limpid, mobile oil, boiling at about 84°, and remaining liquid when subjected to the cold of a mixture of ice and salt. Pure coal-tar benzene contains about 0.5 per cent. of thiophene. (*Ber. d. chem. Ges.*, xvi, 1465.)

The Ethyl Derivatives of Anhydro-benzdiamido-benzine have been treated in a paper by Prof. James Lewis Howe, of the Central University, Richmond, Ky., and published in the *Am. Chem. J.*, v, 418.

Arabic acid has been prepared in a pure state and carefully studied by C. O'Sullivan, who assigns to it the formula $C_{80}H_{142}O_{74}$.

Cryptidin has been synthetically made by Dr. Albert R. Leeds. It has

the formula $C_{11}H_{11}N$. The same chemist describes *œnantholanilin*, *œnantholxylidin*, and *œnantholnaphtylamin*, bodies having agreeable ethereal odors, and yield amorphous sublimates with partial decomposition.—(*Ber. d. chem. Ges.*, XVI, 287 and 289.)

Silicon-ethers of phenol, according to A. Martini and A. Weber, are easily prepared by heating the phenols with silicium tetrachloride. Tetraphenylsilicate and tetraparakresylsilicate are described by them. (*Ber. d. chem. Ges.*, XVI, 1252.)

The Liebig memorial was unveiled at Munich, August 6, 1883. Prof. A. W. Hofmann made the principal address on the occasion, reviewing the influence of Liebig's discoveries in chemistry. A few months after the ceremony, the white marble statue of Liebig was wantonly injured by some black liquid which was thrown over the head and left shoulder. It was feared that the statue was permanently injured, for the black substance had penetrated the pores of the marble. Later advices show that the liquid used was nitrate of silver. One thousand marks reward were offered for the perpetrator. In December the stains were successfully removed.

Frederick Wöhler is fitly honored in the *Berichte der deutschen chemischen Gesellschaft* by a long biography and bibliography prepared by Prof. A. W. Hofmann. Wöhler's contributions to chemical literature number 280. The paper is accompanied by a portrait and a fac-simile letter.

Honors to an American chemist.—The German Chemical Society of Berlin has on its rolls the following sixteen honorary members, representing, as will be seen, a variety of nationalities: R. Bunsen of Heidelberg, J. Dumas of Paris, H. Kopp of Heidelberg, S. Cannizzaro of Rome, E. Frankland of England, R. Fresenius of Wiesbaden, J. S. Stas of Brussels, A. Williamson of London, A. Wurtz of Paris, G. Kirchhoff of Berlin, H. E. Roscoe of Manchester, C. von Marignac of Geneva, F. Abel of Woolwich, A. Butlerow of St. Petersburg, Warren de la Rue of London, and Q. Sella of Rome. The society in 1883 honored itself and recognized the claims of the United States by adding to this distinguished company Dr. Wolcott Gibbs, professor of chemistry in Harvard University, who confessedly stands in the foremost rank of scientific investigators.

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NECROLOGY OF CHEMISTS, 1883.

Dr. J. LAWRENCE SMITH, of Louisville, Ky., died October 12, 1883. Dr. Smith was born near Charleston, S. C., December 16, 1818; was graduated from the University of Virginia, and from the medical department of the University of South Carolina. In early life he followed the profession of civil engineer, but afterward turned his attention to

chemistry and mineralogy, making also a specialty of meteorites. He was the inventor of the inverted microscope, so useful in the study of chemical reactions. In 1851 he was elected professor of chemistry in the University of Virginia, and later to the same chair in the Medical College at Louisville, Ky. During his later years he was the chemist and superintendent of the Louisville Gas Works.

Dr. Smith's original contributions to chemistry and mineralogy are numerous and important; with the smaller papers they aggregate nearly one hundred. He published his collected researches in 1873 in an 8vo volume of 400 pages. These embrace several papers on emery, of both Chester, Mass., and of Asia Minor; several memoirs on meteorites, describing more than twenty-five different specimens, and valuable papers on analytical methods with which his name will always be associated. Dr. Smith was a member of many learned societies, and received high honors from several European Governments.

Dr. LEONARD D. GALE died in Washington, D. C., October 22, in his eighty-fourth year. Dr. Gale was a chemist and physicist and aided Prof. S. F. B. Morse in his early experiments in telegraphy.

CHARLES HERBERT HUTCHINSON, a pharmaceutical chemist, died in London in April, aged 24. He published several original researches, and at the time of his death was assistant to Professor Armstrong at the London Institution.

PETER SPENCE, born at Brechin, Scotland, in 1806, died at Old Trafford July 5, 1883. He founded the Pendleton Alum Works, near Manchester, which were the largest in the world, being capable of producing 200 tons of alum per week. Mr. Spence took out fifty to sixty patents, nearly all for improvements in chemical processes. He was accounted one of the best practical chemists of the day, obtaining this distinction by hard work in the laboratory.

Dr. JAMES YOUNG, the distinguished industrial chemist of Scotland, died near Glasgow, May 14, 1883, in his seventy-first year. His name has long been identified with the paraffin industry, in which he amassed great wealth.

JOHN ELLIOTT HOWARD, a well-known chemist of London, died in November, aged seventy-six years.

Dr. ARTHUR F. TAYLOR, professor of chemistry in the Case School of Applied Science, Cleveland, Ohio, died suddenly in New York City, June 28, aged thirty-two years. Dr. Taylor was born in Andover, Mass., December 10, 1853, was graduated at Dartmouth in 1874, and at the University of Göttingen two years later. He took an active part in the organization of the Case School of Applied Sciences, and his early death removed therefrom a man of bright promise.

Dr. KARL LUDWIG REIMER, an industrial chemist of Prussia, died January 15, 1883. Reimer was born December 25, 1845, in Leipzig. In 1875 he made the neat discovery that salicylaldehyde results from the action of chloroform on phenol in the presence of alkalis.

Prof. WILHELM WEITH, of Zurich, who died November 29, 1881, is honored with a full obituary and portrait in the *Berichte der deutschen chemischen Gesellschaft* for 1882. Weith was born at Homburg May 9, 1846.

Prof. VINZENZ KLETZINSKY died March 18, 1882. He was born July 16, 1826, in Gutenbrunn, Lower Austria. A full notice of his life and labors is published in the *Berichte der deutschen chemischen Gesellschaft* for 1882.

16
RECENT PROGRESS IN CHEMISTRY,

AN ADDRESS

PREPARED AT THE REQUEST OF THE

NEW YORK ACADEMY OF SCIENCES,

AND READ

MARCH 15th, 1886.

BY

H. CARRINGTON BOLTON, PH.D.,

Professor of Chemistry, Trinity College, Hartford.

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1886.

RECENT PROGRESS IN CHEMISTRY.

(1.) To many intelligent and cultivated persons not specifically instructed in chemistry, this word recalls confused memories of colored liquids, glistening crystals, dazzling flames, suffocating fumes, intolerable odors, startling explosions, and a chaos of mystifying experiments, the interest in which is proportional to the danger supposed to attend their exhibition. Further reminiscences are of many singular objects in wood, metal, glass, and earthenware, of flasks and funnels, of retorts and condensers, furnaces and crucibles, together with bottles innumerable filled with solids, liquids, and gases, the whole paraphernalia connected by glass tubes of eccentric curves, and displayed in inextricable confusion and meaningless array. Behind this chaos arise vague memories of one discoursing learnedly in a polysyllabic jargon, and attempting to explain the unusual phenomena by the aid of abstruse hypotheses, but utterly failing to remove the sensations of awe and of mystery bordering on the supernatural which overwhelm the hearer—impressions that have clung to chemistry ever since its entanglement with the superstitions of alchemy, astrology, and the “black art.”

Persons who undertake to gain through chemical literature a knowledge of what chemists are doing in and for the world, encounter a discouraging nomenclature which repels them by its apparent intricacy and its polysyllabic character. Their opinion of the terminology of an exact science is not enhanced when they learn that “black lead” contains no lead, “copperas” contains no copper, “mosaic gold” no gold, and “German silver” no silver; that “carbolic acid” is not an acid, “oil of vitriol” is not an oil, that olive oil is a “salt,” but “rock oil” is neither an oil nor a salt; that some sugars and some kinds of wax are alcohols; that “cream of tartar” has nothing in common with cream, “milk of lime,” with milk, “butter of antimony” with butter, “sugar of lead” with sugar, nor “liver of sulphur” with the animal organ from which it was named.

Readers of chemical writings sometimes fail to appreciate the advantages of styling borax, “di-meta-borate of sodium,” or of

calling common alcohol "methyl-carbinol," and they ignore the euphony in such words as pentamethyldiamidodithiodiphenylamindiodomethylate (a substance begotten and baptized by Dr. Albert Maasen).

Those whose chemical education consisted in attendance on a course of lectures illustrated by experiments performed in their presence, interspersed with occasional recitations from a prosaic text-book which taxed the memory in true Chinese fashion, may be pardoned for retaining very hazy impressions of the true character of the science. On the other hand, many thinking and reading persons recognize the magnitude of the scope and operations of chemistry, and have some appreciation of its benefits to mankind.

(2.) The fields of chemistry explored by zealous investigators are prodigious in extent and diversity; in its various sections, analytical, agricultural, pharmaceutical, physiological, and technological, it yields fruit of infinite value to the human race, and, co-operating with other sciences, produces results which promote civilization in the highest degree. So rapidly are new methods of cultivation applied to these fields, so numerous and active are the workmen engaged in tilling them that the harvest is too abundant for mental storage, and those who survey the operations at a distance are quite unable to apprehend the products. This inability to follow the advances made by chemical science is felt not alone by those whose imperfect and non-technical training has illy fitted them for the task; even the specialist stands aghast at the prospect, and abandoning attempts to apprehend the progress made in all departments, confines his reading and research to a limited number.

The twelve principal Chemical Societies of the world have an aggregate membership of over eight thousand; nearly all of these members are actively contributing to the advancement of chemical science, publishing their results for the most part in periodicals especially devoted to the subject. Excluding Transactions of Societies, and Journals of Physics and Pharmacy, these chemical periodicals issue annually about twenty thousand pages. Bearing these statistics in mind, are we not justified in feeling appalled at the idea of presenting within the compass of an evening's address a review of Recent Progress in Chemistry? Any attempt to do more than glance at a few salient points is obviously out of the question. "Recent" time will of necessity be a somewhat variable quantity, its limits being determined by expediency. We shall also endeavor to bear in mind the fact that we address an audience not exclusively composed of professional chemists.

(3.) Much interest is commonly attached to announcements

of new forms of matter; an interest out of proportion perhaps to the real value of the discoveries. During the last nine years chemists have not failed to sustain this interest, for they have proclaimed no less than thirty-one new elementary bodies. The ambition of these chemists, however, has been greater than their accuracy, for of these thirty-one bantlings but five or six have survived the scrutiny of the doctors, two or three are now in precarious health, and the remainder have been buried or cremated without ceremonies. Of the youthful survivors comparatively little is known; their character is being severely tested, and their future destiny and utility is yet uncertain. The extreme rarity of the minerals in which the new elements have been detected, the excessively small percentages of the new ingredients, the extraordinary difficulties attending their separation from known substances combine to render the investigations laborious, protracted, and costly. From twenty-four hundred kilogrammes of zinc blende, Lecoq de Boisbaudran, the discoverer of gallium, extracted sixty-two grammes of the precious metal; compared with this element, therefore, gold is both abundant and cheap. Ytterbium, Scandium, Samarium, Thulium, and the rest will long remain mere chemical curiosities known to but few; probably the most sanguine will not claim for them a future place among substances of economic value.

(4.) But of far greater importance than the elements themselves is the marvellous delicacy of the means used in detecting and isolating them. When Bunsen and Kirchhof presented to scientists the instrument which combines the penetration of a telescope with the power of a microscope magnified an hundred-fold, they were enabled to disclose nature's most hidden secrets. The new elements have been traced to their hiding-places, their differences established, and their subsequent purity demonstrated, chiefly by their emission and absorption spectra. Three years ago, William Crookes, who had already discovered thallium by the aid of the spectroscope, announced a novel and remarkable extension of the power of this instrument. Crookes found that many substances, when struck by the molecular discharge from the negative pole in a highly rarefied atmosphere, emit phosphorescent light of varied intensity. Having observed under these conditions a bright citron-colored band or line, he pursued the substance producing it, and, after a laborious search, found that it belonged to yttrium. Subsequent studies showed this modification of spectrum analysis to exceed in delicacy all known tests for the rarer earths; yttrium can be detected when present in one millionth part. Within a twelvemonth, Crookes has made known the application of radiant matter spectroscopy to samarium; the delicacy of this test surpasses that for yttrium,

and the anomalous behavior of the mixed earths yields phenomena "without precedent."

About the same date as the later communication by Crookes, Lecoq de Boisbaudran⁶ published a method of obtaining what he terms "reversion spectra," which is practically the same in effect as that of Crookes. The French savant finds indications of two new elements in certain brilliant lines, but Crookes distinctly warns us that "inferences drawn from spectrum analysis *per se* are liable to grave doubt," and "chemistry after all must be the court of final appeal." Crookes' reflections on the sufficiency of spectrum observations as criteria of the elementary character of bodies are justified by the experience of many, notably of Sorby, whose pseudo jargonium is well remembered. This difficulty arises especially with absorption spectra, and neglect of the warning given by Sorby has led several chemists into fruitless researches.

(5.) When Dalton, the Manchester schoolmaster, added to the atomic theory of the Greeks the laws of definite and of multiple proportions, he transformed an "interesting intellectual plaything" into an exact scientific theory capable of experimental demonstration. The importance of ascertaining the atomic weights of the elements with the utmost accuracy has stimulated chemists to apply to the problem their best endeavors; and as the methods of analysis become more refined the determinations are again and again repeated, every ascertainable and imaginable source of error being carefully eliminated. Beside the experimental repetitions, the figures obtained by various observers have recently been submitted to careful re-calculations by Clarke,⁸ in this country, and soon after by Lothar Meyer and Seubert,⁷ in Germany. Their labors give chemists the latest and most reliable constants.

The prevailing, though partly unacknowledged, adherence to Prout's hypothesis, leading chemists to prefer whole numbers (or at least even fractions) for the atomic weights, is liable to result in confusion and perplexity. Stas demonstrated that the atomic weight of oxygen is not quite sixteen times as great as that of hydrogen, but that when $H=1$, $O=15.96$. The tendency to disregard this difference of $\frac{1}{400}$ is unfortunate, since important errors in calculations, based on organic analyses, might result therefrom. Lothar Meyer and Seubert show that in the analysis of compounds of carbon and hydrogen, the error introduced by making $O=16$ is greater than the errors of observation, and in the analysis of a body belonging to a homologous series doubts might arise as to the identity of the body under examination.⁹ Of course, the formula of a body is not determined by analytical data alone; still, this liability to errors marks forcibly the desira-

bility of greater uniformity in the standard of values for the atomic weights.

Contrasting strongly with belief in the absolute character of the weights of atoms is the suggestion of Boutlerow and others that the law of definite proportions is subject to variations. In 1880, Schützenberger observed a curious anomaly in analyzing some hydrocarbons. He found that the sum of the carbon and hydrogen was 101 for 100 parts of material, the result under other conditions being normal. Boutlerow called attention to this, and expressed the opinion that the chemical value of a constant weight (or rather mass) of an element may vary, and that the so-called atomic weight of an element may be simply the carrier of a certain amount of chemical energy which is variable within narrow limits. At a meeting of the Chemical Society of Paris, where Professor Wurtz presented a summary of the views of Boutlerow, an interesting discussion followed; this subsequently drew from Prof. Josiah P. Cooke, of Harvard, a communication in which he shows that he had expressed similar views more than twenty-five years before. As early as 1855, he had questioned the absolute character of the law of definite proportions, and had suggested that the variability was occasioned by the very weak affinity between elements manifesting a fluctuating composition. These speculations are interesting to theorists, but do not seriously impugn the status of chemical philosophy."

(6.) For many years, chemists have dimly perceived the probable correlation of the properties of the elementary bodies and their atomic weights. Dumas pointed this out for certain marked groups, Newlands¹⁹ emphasized it; but it remained for a Russian chemist, Mendelejeff,²⁰ to establish, in 1869, a law of great importance. Mendelejeff showed that if the elements are grouped in the order of their atomic weights, it will be found that nearly the same properties recur periodically throughout the entire series. This so-called Periodic Law is more concisely stated thus: The properties of the elements are periodic functions of their atomic weights. The accuracy of the deductions based on this law is strikingly shown by the fact that Mendelejeff, finding an unfilled blank in the periodic system, boldly announced the general and special properties of the element awaiting discovery; six years later, Lecoq de Boisbaudran discovered gallium, an element which proved to have properties almost identical with those of the hypothetical *eka-aluminium* described by Mendelejeff. And in 1879, the accuracy of Mendelejeff's prophecy was further confirmed by Nilson's discovery of scandium,²¹ the counterpart of the hypothetical *ekabor*. *Éka-silicon*, though yet to be discovered, may almost be regarded as a known element, so fully have its properties been predicted.²²

The correlation between atomic weights and physical properties is being extended, and now embraces the fusibility, boiling-points, general affinities, color, occurrence in nature, physiological functions, and many other factors." Dr. Carnelley," who has been active in developing this subject, at the Aberdeen meeting of the British Association, proposed a "reasonable explanation" of the periodic law; he regards the elements as compounds of carbon and æther, analogous to the hydrocarbon radicals, and suggests that all known bodies are made up of three primary elements, carbon, hydrogen, and æther—an assumption which cannot be disproved.

In recent years the periodic system has exerted noteworthy influence on the classification of the elements and their compounds. It is of positive utility in determining unsettled questions concerning new and rare elements, and is destined to maintain a lasting hold on chemical philosophy.

(7.) The question whether the known elements are truly primary forms of matter has long occupied the thoughts of chemists, and the problem constantly acquires new features. The influence of high temperatures on the spectra of the metals has been a fruitful source of speculations. In 1878, the English astronomer and physicist Lockyer" announced the discovery of the resolution of the elements into one primary matter; but when Lockyer's paper was read before the Royal Society his discovery proved to be little more than a hypothesis, and that not a new one, he having been virtually anticipated by Professor F. W. Clarke, of Washington." However, Lockyer's hypothesis was based in part upon experimental evidence. After eliminating coincidences in the lines of the spectra of various metals, due to impurities, so large a number of identical lines remained that he advocated the assumption that these are produced by a primary matter common to the so-called elements. He pointed out that in the hottest stars, Sirius for example, hydrogen only is present, and argued that at extremely high temperatures the so-called elements are broken up into hydrogen, the ultimate matter of the universe. Lockyer's announcement excited, temporarily, a lively interest, but his views are not regarded as supported by sufficient evidence.

More recently, the doctrine of "structure" has been borrowed from organic chemistry, and applied to the elementary bodies; the relations existing between the elements is so similar in many respects to the relations between the hydrocarbons in a homologous series, that the elements have been regarded as compounds of carbon with an unknown primary form of matter. Experimental evidence is lacking, but the hypothesis takes a plausible form.

Dr. Carnelley, as elsewhere stated, suggests that elements are compounds of hydrogen, with the all-pervading æther of the physicist; but we venture to remark that attempts to explain the nature of elements by assuming them to be compounds of hydrogen with a substance whose very existence is itself assumed, is, perhaps, an intellectual amusement, but not likely to advance the exact sciences.

During the past year an Austrian chemist has announced the decomposition of didymium by purely chemical means, and the discovery of praseodymium and neodymium as its constituent elements.¹⁹ An English chemist claims to have evidence of the existence of an allotropic form of nitrogen.²⁰ Both these statements await confirmation.

(8.) The views of chemists concerning the nature of affinity and chemical action are undergoing modifications destined to wield an important influence on the science in the near future. The notion has prevailed, though not distinctly formulated, that the chemical attraction exerted between unlike atoms is a superior sort of cohesion, powerful and absolute; and this force was thought to operate between two elementary bodies directly, without the intervention of a third kind of matter. That this so-called affinity is radically affected by physical state, by heat, and by electricity has been admitted, but the conviction is growing in the minds of chemists that many circumstances influencing the union and separation of elements have been overlooked; they are beginning to believe that chemical action does not take place between *two* substances, and that the presence of a third body is important, if not, indeed, indispensable. Many years ago the word catalytic was coined to describe certain isolated phenomena little understood. These phenomena are familiar to chemists, and the number is increasing; the word catalytic is, however, in disfavor, and the term contact-actions is now current. The well-known influence of finely-divided and heated platinum in effecting the union of sulphur dioxide and oxygen, and the action of metallic silver in decomposing ozone without itself undergoing any change are examples. In these and similar changes one of the substances indispensable to the reaction remains unchanged, and its rôle cannot be expressed in equations.

Dulong and Thénard,²¹ more than sixty years ago, showed that the temperature of ignition of a mixture of hydrogen and oxygen is lowered to a remarkable degree by the presence of solid bodies of varied nature. Within a few months, Menshutkin and Konowalow²² have made a study of the influence of asbestos, glass, and other bodies on the decomposition-temperature of many organic compounds.

There is another class of reactions in which one body acts

upon another only through the aid of a third, which maintains its identity at the close of the reaction, yet is known to be decomposed and recomposed successively throughout the operation. By heating a relatively small quantity of cobaltous chloride with bleaching powder, the latter is wholly decomposed, yielding calcium chloride, water, and oxygen, yet at the close of the reaction the cobaltous oxide is found unaltered. It has been shown that it is successively decomposed and recomposed during the operation. In their investigation on "Simultaneous Oxidation and Reduction by means of Hydrocyanic Acid," Profs. Michael and Palmer²² consider it probable that many of the most important reactions of animal and vegetable life are due to the intercession of substances which undergo change during the reactions, and in the end return to their original form. They suggest also that some of these reactions seem to be dependent on substances capable of decomposing water into its elements, or into hydrogen and hydroxyl; and when the chemist can command a reagent possessing that property at a low temperature, their imitation in the laboratory may follow its discovery.

(9.) That chemically pure zinc is not soluble in dilute sulphuric acid has been known since Faraday's day; that sodium does not combine with perfectly dry chlorine, even if the metal be heated to its fusing-point, was shown by Wanklyn²⁴ in 1869; more recently, Mr. Cowper has found that dry chlorine does not attack Dutch metal; six years ago, Mr. H. B. Dixon²⁵ demonstrated before the British Association that a well-dried mixture of carbon monoxide and oxygen can be subjected to the electric spark without exploding. In March, 1885, Mr. H. B. Baker²⁶ communicated to the London Chemical Society results of his experiments on the influence of moisture in the combustion of carbon and of phosphorus in oxygen, his conclusions being that the combustion of dry charcoal in dry oxygen is incomplete and slower than in ordinary moist oxygen. In the discussion which followed Mr. Baker's paper, Dr. Armstrong pointed out the importance of these new facts in defining more accurately conceptions of chemical action, and suggested that chemical action is "reversed electrolysis." In his address as president of the chemical section of the British Association for the Advancement of Science (Sept. 10, 1885), Dr. Armstrong further discussed this subject, and stated that the idea conveyed by the expression "reversed electrolysis" is found in the writings of Faraday, neglect of whose teachings retards the progress of chemistry.²⁷

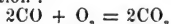
The influence of low and of high temperatures in retarding and facilitating chemical changes is fundamental, but some phenomena not generally known may be appropriately mentioned. Victor Meyer and Langer²⁸ have shown that whereas chlorine

violently attacks platinum at low temperatures, it is without action upon the metal between 300° and $1,300^{\circ}$, and begins to act upon the platinum above the latter temperature, the action becoming violent at $1,600^{\circ}$ to $1,700^{\circ}$ C.

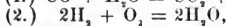
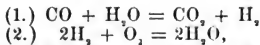
Liquefied ammonia at -65° does not combine with sulphuric acid, but swims on its surface without mixing with it.²⁸ Donny and Mareska²⁹ long ago showed that sodium retains its luster in liquid chlorine at -80° , and quite recently Prof. Dewar demonstrated that liquid oxygen is without action on sodium, potassium, phosphorus, solid sulphuretted hydrogen, and solid hydriodic acid. He further experimented with other substances normally active, and found their affinity at very low temperatures destroyed.³⁰

(10.) Attempts have been made to solve the problem of a general theory of chemical action by means of the data of electrolysis and of thermo-chemistry. The subject is further complicated by the phenomena of induction, of predisposing affinity, and of influence of mass. Lastly, but not least, the term affinity is itself used in a vague way, expressing different ideas at different times and by different authors, some writers doubting the expediency of employing the word at all, and favoring the more general expression chemical action. The true nature of chemical action has yet to be satisfactorily explained; only the most general conclusions are fairly deducible from the data in hand, namely: "that each chemical substance which forms a member of any changing system exerts a specific action on the course of the changes which that system undergoes."³¹

Chemists are beginning to realize that many phenomena regarded as simple in character are in reality quite complex. A single example must suffice. From Lavoisier's day until a few years ago the combustion of carbon monoxide in the air, or in oxygen was regarded as a very simple phenomenon, satisfactorily explained by the equation:



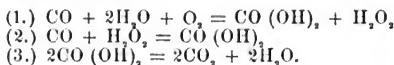
in which two molecules of the gas unite directly with one of oxygen, producing two molecules of carbon dioxide. In 1880, however, Mr. H. B. Dixon³² demonstrated that this reaction takes place only in the presence of aqueous vapor; this necessitates an entirely different explanation, as indicated in the following equations:



that is to say, the carbon monoxide decomposes the water forming carbon dioxide and setting hydrogen free, which latter gas unites with the free oxygen and thus reconstructs the water.

Within a twelvemonth, however, Traube³³ has shown that

carbon monoxide does not decompose water in complete absence of air or oxygen, and hence Dixon's first equation does not represent a fact. Traube also finds that when moist carbon monoxide and oxygen are united by the electric spark, hydrogen peroxide is an invariable product, and he suggests the following explanation of the reaction :



These equations may be interpreted as follows: When the electric spark is passed through a mixture of carbon monoxide and oxygen in the presence of aqueous vapor, the first products are true carbonic acid and hydrogen peroxide; the latter at once oxidizes the carbon monoxide, forming a second molecule of carbonic acid; and, finally, the two molecules of carbonic acid are decomposed with the formation of carbon dioxide and water.

If Traube's views be sustained, it is evident that so simple a matter as the combustion of carbon monoxide has long been misunderstood, and disregard of the presence of moisture has led to erroneous conclusions.³⁴

Chemists sometimes marvel at the blindness of the alchemists who, though familiar with many chemical processes in which gaseous bodies were evolved, yet disregarded these important factors, and left them for later generations to discover. What will future generations think of us who fail to take into account accessory bodies indispensable to chemical reactions of the most familiar kind.³⁵

(11.) The speed of chemical reactions is an important factor in chemical theory, the study of which has but recently begun. Wenzel³⁶ long ago held that the affinity of metals for a common solvent, such as nitric acid, was inversely as the time necessary to dissolve them, and he experimented with small cylinders, partly protected by wax. Gladstone and Tribe³⁷ have made attempts to ascertain the rate at which a metallic plate precipitates another metal from a solution, and they announced a definite law. Prof. John W. Langley³⁸ has since shown that, while their experimental work was correct, their method was faulty, and the results fallacious; he thinks it probable that the true law of chemical action where one metal precipitates another should be thus stated: The time during which one atom replaces another in a compound molecule is constant, and the total rate of chemical action varies directly as the mass of the reacting body in solution.

In his address before the Chemical Section of the American Association for the Advancement of Science, at Philadelphia,

Professor Langley²² discussed the problems of chemical dynamics, and pointed out the rich store of promise in this neglected field. Physics deals with three quantities—space, mass, and time. Chemistry has too long been content with studying the changes of matter in terms of space and mass only, that is to say, in units of atomic weight and atomic volume. The discovery of a time-rate for the attractions due to affinity is destined to throw new light on chemical science, and to render it capable of mathematical treatment.

(12.) A prodigious amount of work has been done in thermo-chemistry, and within a few years, the multitude of isolated observations have been collected, classified, and made available. The importance of this undertaking will be more appreciated in the future than it has been in the immediate past.

In all cases of chemical change, energy in the form of heat is either developed or absorbed, and the amount is as definite in a given reaction as are the weights of the substances concerned; hence, measurement of the quantity of heat set free or absorbed in chemical reactions often enables the chemist to determine the true nature of the change. For example, the exact condition of certain bodies in solution can only be conjectured from certain physical characters, few and ill-defined; but by thermic methods of investigation the bodies formed can be accurately ascertained. This is accomplished by reference to the law of maximum work. "In any reaction, those bodies, the formation of which gives rise to the greatest development of heat, are formed in preference to others." Thus the thermometer alone in skilful hands determines the *à priori* necessity or impossibility of a reaction.²³

Berthelot,²⁴ in Paris, and Thomsen,²⁵ in Copenhagen, have pursued the subject of thermo-chemistry with indefatigable zeal, and their published results form monuments of exhaustive research. "By the labors chiefly of these two men, we now know the thermal values corresponding to many thousands of chemical reactions. We have learned that the energies of a reaction which can be brought about in two methods, either in the dry way or by solution, differ in the two cases; that salts in solution are in a partial state of decomposition; that the attraction of a polybasic acid radical is not the same for the successive portions of base added, and that the behavior of a monobasic acid in solution differs essentially from that of a dibasic or tribasic acid. We also know that the total energy involved in any reaction is largely influenced by the surrounding conditions of temperature, pressure, and volume."²⁶

(13.) The interesting border line between chemistry and physics is an increasing subject of research on the part of both the chemist and the physicist. The periodic press chronicles

profound studies of the relations between chemical constitution and the phenomena of diffusion, of capillarity, of dialysis, of dissociation, and of the law of isomorphism. We read investigations on the value of the theory of atomicity, and on the nature of nascent action. Researches in the domain of electro-chemistry, especially in connection with the various forms of storage batteries, and in relation to the methods and results of electrolysis, are of such importance as to merit a whole address. The press also records numerous studies in actinometry, of the relations between chemical composition and fluorescence and phosphorescence, as well as of polychroism, and of the results of spectrum observations. Noteworthy are the special applications of optical methods to the determination of molecular structure, viz., the relations between chemical composition and (1) the refractive power; (2), the power of rotating a ray of polarized light; and (3), the absorption spectra of both inorganic and organic bodies.

Bruhl has attempted to show that the relationship between refractive power and molecular structure is dependent on the valencies of atoms, and on the distribution of atomic interactions. Van 't Hoff has developed a hypothesis of a crystallographic character that cannot be discussed in the brief space at our command."

(14.) The meeting of the French Academy of Sciences, held the day before Christmas, 1877, was rendered memorable by the announcement that oxygen gas had been liquefied by two independent experimenters. Previous to that date, hydrogen, oxygen, nitrogen, nitric oxide, marsh gas, and carbon-monoxide had resisted all attempts to liquefy them, whether in the hands of the skilful Faraday, the ingenious Natterer, or the learned Andrews. Physicists and chemists, while admitting the class of so-called permanent gases, had for many years looked forward to their eventual liquefaction, yet the final success came as a surprise. This success was the result of the enterprise and ingenuity of a French iron-master, M. Cailletet, and of a Genevan manufacturer of ice-machines, Raoul Pictet, working independently. In each case, the process consisted in simultaneously exposing the gases to a very high pressure and a very low temperature. Pictet obtained the necessary pressure by generating the oxygen in a wrought-iron vessel strong enough to withstand an enormous strain, and the low temperature was secured by the rapid evaporation of liquid carbonic acid; Cailletet, whose apparatus was marked by extreme simplicity, obtained the great pressure by means of a hydraulic press, and the low temperature by suddenly diminishing the pressure upon the compressed gases. Descriptions of apparatus without diagrams are seldom intelligible; in

this place they are superfluous, for we deal with results rather than with methods. Being ignorant of the "critical point" for oxygen, both experimenters employed a much greater pressure than necessary.

Since the initial successes, the problem of liquefying the quondam permanent gases has been successfully attacked by several experimenters, especially by Wroblewski and Olzewski, whose names indicate their nationality.* By employing liquid ethylene (which boils *in vacuo* as low as -150°C. [-238°F.]) as a means of cooling the gases under pressure, both oxygen and nitrogen, as well as atmospheric air have been liquefied at very moderate pressures.

Among the interesting results obtained are the following: at -102°C. (-152°F.), chlorine forms orange-colored crystals; at -115°C. (-175°F.), hydrochloric acid is a solid; at -118°C. (-180°F.), arsenetted hydrogen forms white crystals; at -129°C. (-200°F.), ether solidifies; at -136°C. (-202°F.), absolute alcohol solidifies; at -184°C. (-299°F.), oxygen boils; at -191.2°C. (-312°F.), air boils; at -205°C. (-337°F.), air boils *in vacuo*. These extraordinary temperatures were measured by means of an hydrogen thermometer, and by a thermo-pile. The lowest temperature measured (to date) is -225°C. (-373°F.), which was reached by reducing the pressure of solid nitrogen to 4 mm. mercury" (Olzewski). Further noteworthy results are as follows: nitrogen was obtained in "snow-like crystals of remarkable size;" the liquefaction of air has been so conducted as to obtain two distinct liquids separated by a perfectly visible meniscus (Wroblewski)," and, finally, when hydrogen was subjected to between 100 and 200 atmospheres pressure in small glass tubes surrounded by oxygen boiling *in vacuo*, it condensed to colorless drops.

These noteworthy results are triumphs of physics rather than of chemistry, but no review of chemical progress can afford to omit them; their bearing on the molecular theory of matter justifies the space given them. It seems probable, moreover, that every known substance on the face of the earth will be eventually obtained in solid form by the mere withdrawal of heat. At these low temperatures the chemical activity of bodies is greatly lessened or ceases, but additional observations must be made on this point before attempting generalizations.

Experiments of the character described demand great resources and are not devoid of danger; those conducting them will be rewarded by undying fame.

(15.) The progress of chemistry in its more material aspects is characterized by the improved and economic production of known substances, by the discovery and manufacture of entirely

new ones, and by novel applications of both these classes as well as of waste materials. The necessity of utmost condensation precludes enumeration of even a centesimal part of the processes and products, nor would the mere catalogue be profitable. Omitting for the present the prolific department of organic chemistry, brief mention may be made of improvements in the metallurgy of nickel⁶⁰ (now known to be malleable and ductile), of attempts to cheapen the production of aluminium,⁶¹ of the revival of the barium dioxide process for manufacturing oxygen on a large scale,⁶² of novelties in artistic ceramics, of the industrial production and application of the rare metal vanadium, of the successful introduction of water gas as an illuminating agent, and of constant activity in the fascinating field of photography.

No chemical manufactures are more important than those grouped under the name: "Alkali industry," which comprises the production of those adjuncts of civilization, carbonate of soda, caustic soda, bicarbonate of soda, and bleaching powder. Conducted by the methods originated by the ill-fated Nicolas Leblanc, they have, after a century's successful career, begun to give way to a youthful rival. The struggle to maintain the supremacy of Leblanc's process has been severe, the problem being a purely financial one. At first, the profits were made exclusively on the soda, then the decreasing profits, as well as the necessity of condensing the torrents of hydrochloric acid, led manufacturers to add to the production of alkali that of bleaching powder, and the latter then yielded the profits while the soda became a bye-product. Sharp competition in England and France pushed prices below profitable production, and capitalists with millions involved found their chemical ingenuity severely taxed. Various economical methods of recovering waste bye-products were adopted, and finally attention was turned to the "burnt ore" or "pyrites cinders" obtained in roasting pyrites for the sulphuric acid; this is now treated for copper, silver, and, to some extent, for gold. A Spanish company owning enormous deposits of pyrites on the Rio Tinto, plan to establish in France alkali works with the intention of deriving their profits solely from the residual oxide of iron and the copper.

Forty-eight years ago alkali manufacturers might have seen a cloud arising, no bigger than a man's hand, which gradually grew darker and heavier, and now threatens to overwhelm the Leblanc process. Dyer and Hemming patented the so-called "ammonia process" for manufacturing soda in 1838; Schlössing and Rolland attempted to carry it out practically in 1855, but it was not found profitable. The credit of overcoming the practical difficulties, and placing the process on an economical basis, belongs to Solvay, of Brussels, who began to manufacture so-

called "ammonia-soda" in 1866. Commencing with the modest yield of 179 tons in that year, he increased it in ten years to 11,580 tons, and in 1883, about 40 per cent of all the soda made on the continent was produced by the ammonia process. The success of the new process has completely killed the Leblanc method in Belgium, and has caused the closing of many works in England. A drawback to the new process is that no hydrochloric acid is produced, yet chloride of lime is always in demand; hence a high authority, Dr. Lunge, thinks that in the future the two processes will, of necessity, exist side by side."

(16.) In modern chemical literature by far the greatest amount of space is occupied with researches and discoveries in organic chemistry. To the non-professional reader the peculiarly technical language, abounding in words of unusual length, is not only incomprehensible, but positively forbidding. A vocabulary which contains such terms as tolyldiphenyltriimidocarbinol acetate and methylorthomonohydroxybenzoate does not encourage the casual reader; and when he learns the first-named body is the dye-stuff commonly called magenta, and that the second is the innocent oil of wintergreen, surprise gives way to feelings of despair. When one is gleefully informed that a distinguished foreigner has discovered that orthobrombenzyl bromide treated with sodium yields anthracene, which, heated with nitric acid, yields anthraquinone, and that anthraquinonedisulphonic acid fused with potassium hydroxide furnishes dioxyanthraquinone, the lay hearer can hardly be expected to become enthusiastic over the announcement, and yet these operations conducted in the private laboratory of a man of genius have been of direct benefit to mankind, setting free thousands of acres for the production of breadstuffs, and establishing industries employing a multitude of workmen. In a word, these abstruse phrases describe the artificial production of alizarine, the valuable coloring matter of madder.

The polysyllabic nomenclature now prevailing expresses to the chemical mind the innate structural composition of the body named; of late years the words are formed by joining syllables to an almost indefinite extent, and a distinguished chemist has recently urged the advantages of empiric names in place of the unwieldy system. Whether Dr. Armstrong's plea will produce a reaction in favor of empiric names remains to be seen.

(17.) To enter into details concerning the recent progress of organic chemistry, and to make them intelligible to an audience not composed of well-read professional chemists, is an undertaking of doubtful success; we shall content ourselves chiefly with generalities.

That remarkable product of nature, petroleum, continues to occupy the studies of chemists at home and abroad. Newly in-

vented methods of fractional distillation have disclosed previously unsuspected constituents and peculiarities. Lachowitz has found in the petroleum of Galicia several members of the aromatic series;⁵⁵ Mendelejeff has noticed abnormal relations between the specific gravity and boiling-points of successive fractions in distilling American petroleum.⁵⁶ The various commercial products from crude petroleum, rhigolene, vaseline, paraffin, etc., continually find new and useful applications, their names being household words.

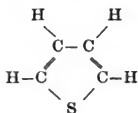
The industrial and scientific novelties in the important groups of oils and fats, alcohols, and acids, cannot be specified. After cane-sugar, glucose is receiving the most attention; in the U. S. and Germany are sixty manufactories of the various grades of starch-sugar, the annual home production alone being valued at \$10,000,000. Glucose is extensively used as a substitute for cane-sugar in the manufacture of table syrup, in brewing, in confectionery, in making artificial honey, and in adulterating cane-sugar, as well as in many minor applications. Recent experiments by Dr. Duggan,⁵⁷ of Baltimore, show that glucose is in no way inferior to cane-sugar in healthfulness. Much work has been done on sorghum by Dr. Peter Collier,⁵⁸ and the first complete examination of maple-sugar has lately been made by Prof. Wiley,⁵⁹ of the Department of Agriculture. Lovers of the latter sweet will be pleased to learn that it can be made by adding to a mixture of glucose and cane-sugar a patented extract of hickory bark which imitates the desired flavor.

The great demand for high explosives as adjuncts to engineering, mining, and military operations occasions constant experimentation; besides the invention of mere empiric mixtures of known substances, chiefly nitro-compounds, much work is done of a purely scientific nature, such as investigations on the chemical reactions and products of explosive mixtures, on the heat disengaged by their explosion, on the pressure of the gases produced, and on the duration of the explosive reaction. Thanks to the "Notes" of Prof. C. E. Munroe⁶⁰ of the U. S. Naval Academy, chemists are informed of the freshest novelties in this department, rendering further mention superfluous.

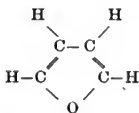
(18.) The researches of chemists in the aromatic series outweigh in both number and importance those in all other sections. The once despised refuse coal-tar has created an entirely new chemistry, and, in its products and derivatives, is by far the most promising field for investigators. The compounds of the aromatic series have afforded some of the most notable successes in synthetical chemistry, as well as some of the most useful substances for dyeing, for hygienic and medicinal purposes. The oil obtained in the dry distillation of bones, a subject of classic investigations by Anderson,⁶¹ of Glasgow, forty years ago, has re-

cently acquired new interest; one of its constituents, pyridine (C_5H_5N), has been obtained in several ways, which show that it bears the same relation to certain acids derived from natural alkaloids, such as quinine, nicotine, etc., that benzene does to benzoic and phthalic acids. These facts point to the possible artificial preparation of quinine at no distant day. This view of the constitution of the alkaloids is confirmed in many ways, notably by Ladenburg's discovery that piperidine, a base occurring in pepper, is hexahydrobenzene.⁵²

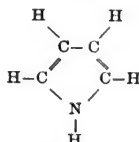
The discovery, by Victor Meyer,⁵³ of thiophene, a constituent of coal-tar benzene, having sulphur in its composition, is of more than passing interest. Meyer assigns to thiophene a structural formula, which shows its analogy to furfuran and to pyrrol. This is indicated in the following graphic formulæ:



Thiophene.



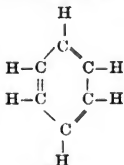
Furfuran.



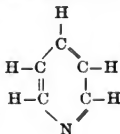
Pyrrol.

(19.) Professional chemists note with interest the important avenues of research opened up by the extension of the so-called ring structure of carbon compounds, and by the introduction of elements other than carbon into the closed chain of atoms. The demonstration by Kekulé, in 1865, that benzene contains a group of carbon atoms joined in such way as to form a regular hexagon, has wonderfully advanced our knowledge of the complex bodies in the aromatic series.

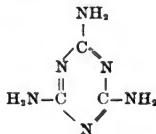
Numerous bodies are now known whose structure is expressed by closed chains of three, four, five, and six links. Dewar⁵⁴ was the first, we believe, to show that nitrogen can replace one of the carbon atoms of a six-link chain in pyridine, and Hofmann⁵⁵ has shown that three atoms of nitrogen and three of carbon unite to form a closed chain in melamine :



Benzene.



Pyridine.



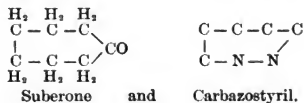
Melamine.

It has been a matter of surprise that no series intermediate between the open chains of the paraffin group and the closed ring of the benzene group have been made known. Quite recently, W. H. Perkin, Jr.,⁶⁶ in a remarkable memoir, has begun to fill up this wide gap, and he describes many bodies containing a three-carbon atom ring, a four and a five-carbon atom ring. The series of possible methylene-addition products is shown in the following schedule:

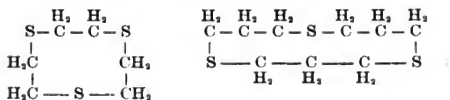
Methylene.	Di-methylene.	Tri-methylene.
$=CH_2$	$\begin{array}{c} CH_2 \\ || \\ CH_2 \end{array}$	$\begin{array}{c} H_2 \\ \diagup \quad \diagdown \\ C \\ \diagdown \quad \diagup \\ H_2C - CH_2 \end{array}$
Tetra methylene.	Penta-methylene.	Hexa-methylene.
$\begin{array}{c} H_2C-CH_2 \\ | \quad | \\ H_2C-CH_2 \end{array}$	$\begin{array}{c} H_2 \\ \diagup \quad \diagdown \\ C \\ \diagdown \quad \diagup \\ H_2C \quad CH_2 \\ | \quad | \\ H_2C - CH_2 \end{array}$	$\begin{array}{c} H_2 \\ \diagup \quad \diagdown \\ C \\ \diagdown \quad \diagup \\ H_2C \quad CH_2 \\ | \quad | \\ H_2C \quad CH_2 \\ \diagdown \quad \diagup \\ C \\ | \\ H_2 \end{array}$

For details concerning derivatives of the above series, and the remarkable properties of some, we must refer to Perkin's published papers.

Professor Victor Meyer⁶⁷ has, within a few months, begun to investigate the possibility of obtaining closed chains containing a greater number of chains than six. He points out that, with the exception of the double rings, such as anthracene and acridine, only two bodies were known having seven links in a closed chain, viz.:



Professor Meyer, however, obtained bodies having nine and twelve links in closed chains, as indicated below.



These are substances of little stability, as indeed might be expected.

Professional chemists also acknowledge the marvellous success in unravelling the complications of isomerism, and the important aid afforded the study of isomeric bodies of the aromatic group by the doctrine of *orientation*. These rather technical details can receive, however, but brief mention, though a whole series of lectures could be devoted to the fascinating topic. Leopold Gmelin, when writing his "Handbook of Chemistry," in 1827, requested organic chemists to stop making discoveries, or else he could never finish! And during the sixty years which have elapsed, the activity in organic chemistry has been unceasing; yet the extraordinary number of facts now known is not so great as those which the prophetic eye sees disclosed by these recently revealed lines of investigation.

(20.) The crowning glory of chemistry is the power of producing, in the laboratory, from inorganic matter, substances identical with those existing in the vegetable and animal kingdoms. Belief in the mysterious vital force operating in living beings received a rude shock at the hands of Wöhler, sixty years ago, and successive triumphs in synthesis have dispelled it entirely, so far as non-organized bodies are concerned: "to-day we know that the same chemical laws rule animate and inanimate nature, and that any definite compound produced in the former can be prepared by synthesis as soon as its chemical constitution has been made out." Within a few years chemists have announced the synthesis of many acids, essential oils, alkaloids, glucosides, dye-stuffs, and other bodies naturally occurring in the organic world, and so rapidly do these announcements succeed one another that expectation has displaced surprise. Noteworthy are the following: alizarine, the valuable coloring matter of madder;⁶⁶ vanilline, the aromatic principle of the vanilla bean;⁶⁷ cumarine, the aromatic principle of the tonka bean;⁶⁸ indigo, the well-known dye-stuff;⁶⁹ uric acid, an animal product;⁷⁰ tyrosin, likewise a product of the animal organism;⁷¹ salicine,⁷² daphnetine and umbelliferone,⁷³ natural glucosides and related bodies; piperidine,⁷⁴ a constituent of pepper; and cocaine, the new anæsthetic.⁷⁵ Besides these, many syntheses have been accomplished of bodies isomeric and not identical with the natural products.

The alchemists labored to transmute base metals into noble ones, and were destined never to realize their ambitious designs; modern organic chemists, operating on substances compared with which even the base metals are precious, produce articles more beneficial to mankind than gold itself, and, at the same time, gain, indirectly, no small store of the coveted metal.

(21.) The application of chemistry to physiology encounters the most complex and difficult problems in the science, and at the same time aims to accomplish the most beneficent results. "The physiologist complains that probably ninety-five per cent of the solid matters of living structures are pure unknowns, and that the fundamental chemical changes which now occur during life are entirely shrouded in mystery. It is in order that this may no longer be the case that the study of carbon compounds is being so vigorously prosecuted." "It may seem strange to the non-professional in this audience that, in spite of persistent and skilful attempts to solve the problem, chemists are obliged to admit ignorance of the exact composition of so common a substance as the white of egg, yet until they acquire an accurate knowledge of the constitution of albuminous substances, the processes of animal economy cannot be explained. While the physiologist, in some degree, waits on the organic chemist for further developments, the latter discovers and prepares novel bodies much faster than the physiologist ascertains their influence on the animal economy. To the joint labors of chemists and physiologists are due the blessings of anæsthetics, hypnotics, and other conquerors of suffering and disease. The anæsthetic properties of cocaine, and the circumstances of their discovery are matters of popular knowledge. Within a twelvemonth, ethyl-urethane has been added to the list of hypnotics.

In recent years, sanitary chemistry has acquired great importance, and now occupies a distinctly defined field, including all that pertains to the hygienic value of foods and beverages, their adulterations, and their fraudulent substitutes; questions of gas and water supply; of the uses and abuses of disinfectants; of household ventilation, and of the diverse matters grouped under the term chemical engineering. Of this very practical branch of chemical science, as well as of the valuable additions to *materia medica*, of the improved methods introduced into analytical chemistry, and of the ever increasing contributions to the chemistry of agriculture, no mention can be attempted.

(22.) The tendency of modern researches in chemistry is to magnify the atomic theory; the rapid accumulation of facts, the ever increasing ingenious hypotheses, the most searching examinations of co-ordinate laws, all tend to strengthen the Daltonian adaptation of the philosophic Greeks. Here and there a voice is

raised against the slavish worship of picturesque formulæ; but against the molecular theory underlying the symbolic system so depicted, few earnest arguments are advanced. The whole aim of organic chemistry is directed to the discovery of the arrangement of atoms within the molecule, and the success obtained justifies the hypothesis. The edifice erected through these achievements, though young in years, is too substantial to tolerate displacement of its corner-stone. The absolute truth of the atomic theory is beyond man's power to establish; even admitting that it necessitates absurd assumptions, it is, nevertheless, indisputably the "best existing explanation of the facts of chemistry as at present known."

A noteworthy feature of existing chemical research is the recognition of the necessity of a more intimate knowledge of the connection between physical characters and chemical constitution. In the past, chemists increased the number of new compounds so rapidly, that they often neglected detailed examination of their physical properties, their relations to known bodies and to each other, preferring to satisfy their ambition by fresh discoveries. This race after new bodies still continues, but parallel with it are zealous investigators striving after a knowledge of the innate qualities and bearings of these same bodies; and the latter class of students is gaining prizes no less valuable than those secured by the former.

Chemists are also recognizing the necessity of a more minute study of the simpler phenomena of chemistry, and it is in this direction they look for many laurels in the future. Priestley's day of great discoveries by the simplest means has in one sense passed; the opportunities for isolating nine new gases, or of recognizing by chemical tests half a dozen new elementary bodies in the space of a lifetime, are gone; only by the employment of the most delicate appliances, by the closest scrutiny of phenomena and the conditions governing them, by availing themselves of all the resources of physics, by an unshrinking expenditure of time and of money, to say nothing of the necessity of trained mental powers of no low order and of skilled hands, shall chemists in succeeding generations realize their ambitious designs.

NOTES AND AUTHORITIES.

(1.) The membership in these Societies is distributed as follows:

Deutsche chemische Gesellschaft zu Berlin.....	2,950
Society of Chemical Industry (England).....	2,000
Chemical Society of London.....	1,500
Société chimique de Paris.....	580
Institute of Chemistry of Great Britain and Ireland.....	430
American Chemical Society.....	250
Society of Public Analysts (England).....	180
Chemical Society of St. Petersburg.....	160
Associazione chimico-farmaceutica fiorentina.....	*200
Chemical Society of Tokio, Japan.....	83
Chemical Society of Washington, D. C.....	48
Association of Official Agricultural Chemists (U. S. A.)..	17

Total..... 8,378

(2.) *New Elements Announced Since 1877.*

DATE.	NAME.	SOURCE.	DISCOVERER.
1877	Davyum.....	Platinum ores....	Sergius Kern.
	Neptunium.....	Columbite.....	Hermann.
	Lavesium.....	Pyrite.....	Prat.
	Mosandrum.....	Samarskite.....	J. L. Smith.
1878	"New earths"....	Unnamed mineral.	Gerland.
	Philippium.....	Samarskite.....	Delafontaine.
	Decipium.....	Samarskite.....	Delafontaine.
	Ytterbium.....	Gadolinite.....	Marignac.
	"X".....	Gadolinite.....	Soret.
1879	Scandium.....	Gadolinite.....	Nilson.
	Norwegium.....	Gersdorffite.....	Dahll.
	Samarium.....	Samarskite.....	Lecoq de Boisbaudran.
	Uralium.....	Platinum.....	Guyard.
	Barcenium.....	Misapprehension..	Editor Wagner's Jahresb.
	Thulium.....	Gadolinite.....	Cleve.
	Holmium.....	Gadolinite.....	Cleve.
	Columbium.....	Samarskite.....	J. L. Smith.
	Rogierium.....	Samarskite.....	J. L. Smith.
	Vesbium.....	Lava.....	Scacchi.
1880	Comesium.....	.....	Kaemmerer.
	Y α and Y β	Gadolinite.....	Marignac.
1881	Actinium.....	Zinc ores.....	Phipson.
1882	Di β	Gadolinite.....	Cleve.
1883	Nameless.....	Platinum ores....	Th. Wilm.
1884	Idunium.....	Lead vanadate....	Websky.
1885	Neodymium.....	Didymium.....	Welsbach.
	Praseodymium....	Didymium.....	Welsbach.
	Z α	Didymium.....	Lecoq de Boisbaudran.
	Z β	Didymium.....	Lecoq de Boisbaudran.
1886	Z γ	Terbia.....	Lecoq de Boisbaudran.

* Estimated. Many chemists are members of several of the above societies, but against this duplication may be set those not connected with societies.

- (3.) Chem. News, XLVII., 261 (1883).
- (4.) Chem. News, LI., 301 (read to Royal Society June 18th, 1885).
- (5.) Comptes rendus, C., 1437 (June 8th, 1885).
- (6.) F. W. Clarke. A Recalculation of the Atomic Weights. Part V., Constants of Nature. Smithsonian Institution. Washington, 1882.
- (7.) L. Meyer und K. Seubert. Die Atomgewichte der Elemente aus den Originalzahlen neu berechnet. Leipzig, 1883.
- (8.) Ber. d. chem. Ges., XVIII., 1089 (1885).
- (9.) Am. J. Sci. (3), XXVI., 63 and 310 (1883).
- (10.) John A. R. Newlands. On the Discovery of the Periodic Law, and on Relations among the Atomic Weights. London, 1884.
- (11.) Liebig's Annalen. Suppl. Bd. VIII., 133. Also Chem. News, XL. and XLI.
- (12.) Ber. d. chem. Ges., XIII., 1439.
- (13.) Chem. News, XLI., 83.
- (14.) Sestini. Gazz. chim. ital., XV., 107.
- (15.) Thomas Carnelley. Ber. d. chem. Ges., XVII., 2151 and 2287.
- (16.) Nature, XXXII., 539 (1885).
- (17.) Proc. Roy. Soc., XXVIII., 159, and XXIX., 247 and 266.
- (18.) Pop. Sci. Monthly. New York, Feb., 1876, p. 436.
- (19.) Chem. News, LII., 49 (1885).
- (20.) Chem. News, LII., 34 (1885).
- (21.) Ann. chim. phys., XXIII. and XXIV. (1823).
- (22.) Ber. d. chem. Ges., XVII. and XVIII.
- (23.) Am. Chem. J., VII., 189 (1885).
- (24.) Chem. News, XX., 271.
- (25.) Nature, XXVIII., 551, and Chem. News, XLVI., 151.
- (26.) Chem. News, LI., 150 (1885).
- (27.) Chem. News, LII., 135 (1885).
- (28.) Meyer und Langer. Pyrochemische Untersuchungen. Leipzig, 1885.
- (28A.) Wurtz Dictionnaire, I., 220.
- (29.) Comptes rendus, XX., 817 (1844).
- (30.) Chem. News, LI., 27.
- (31.) Cf. Pattison Muir. Principles of Chemistry. Cambridge, 1884.
- (32.) Chem. News, XLVI., 151.
- (33.) Ber. d. chem. Ges., XVIII., 1890 (1885.)
- (34.) Since writing the above, Dixon has read another paper on the subject, in which he rejects Traube's views. Nature, XXXIII., 286 (1886).
- (35.) The decomposition of potassium chlorate affords another case in point. The exact manner in which heat affects this salt is yet under discussion. See Dr. Teed's results in Chem. News, LII., 248 (1885), and LIII., 56 (1886). And compare Maumené, Bull. soc. chim., XLV., 51 (1886).
- (36.) Wurtz Dictionnaire de chimie, art. *Affinité*.
- (37.) Proc. Roy. Soc., XIX., 498.
- (38.) Proc. Am. Assoc. Adv. Sci., XXXIII., 185 (1884.)
- (39.) Idem, p. 141. Cf. R. B. Warder. Proc. Am. Assoc. Adv. Sci., XXXII., 156.
- (40.) Wurtz Dictionnaire, art. *Thermochimie*.
- (41.) Essai de mécanique chimique. Paris, 1879, 2 vols.
- (42.) Thermo-chemische Untersuchungen. Leipzig, 4 vols., 1882-'86.
- (43.) J. W. Langley. Proc. Am. Assoc. Adv. Sci., XXXIII., 153.
- (44.) Pattison Muir. Principles of Chemistry. Cambridge, 1884, p. 306.

- (45.) Comptes rendus, LXXXV., 1214 and 1220.
- (46.) Ann. chim. phys. [5], XV., 132.
- (47.) Comptes rendus, XCVI., 1140 *et seq.*, and Chem. News, XLIX.,
- 13. Also Comptes rendus, XCVIII., Jan. 28th, 1884.
- (48.) Olzewski. Comptes rendus, C., Feb. 9th, 1885.
- (49.) Chem. News, LII., 201 (1885).
- (50.) Fleitman in 1879. Cf. Chem. News, L., 3 (1884).
- (51.) Dingler's polyt. J., 1882.
- (52.) Nature, XXXII, 354 (1885).
- (53.) Chem. News, XLVII., 67, and L., 41.
- (54.) Nature, XXXII.
- (55.) Liebig's Annalen, CCXX., 168.
- (56.) Protok. Russ. phys. chem. Ges., 1884, 458.
- (57.) Report on Glucose prepared by the National Acad. Sci. U. S. Internal Revenue. Washington, 1884.
- (58.) Sorghum, its Culture and Uses. Press of the Chamber of Commerce. New York, 1885.
- (59.) Sugar Industry of the United States. Dept. Agriculture, Chemical Division, Bulletin No. 5. Washington, 1885.
- (60.) Notes on the Literature of Explosions, in Proceedings U. S. Naval Institute, Nos. 20, 21, 22, 24, 27, 29, 32, 33.
- (61.) Trans. Roy. Soc. Edinburgh, XVI. (1849), and XX. (1851).
- (62.) Ber. d. chem. Ges., XVII., 514 (1884).
- (63.) *Idem*, XV., 2893, and XVI.
- (64.) Zeitschr. f. chem., 1871, 117.
- (65.) Ber. d. chem. Ges., XV.
- (66.) Journ. Chem. Soc., London, 1885.
- (67.) Naturwiss. Rundschau, I., 1. (1886).
- (68.) Graebe und Liebermann. Liebig's Annalen, Suppl., Bd. VII., 300.
- (69.) Tiemann, Ber. d. chem. Ges., VII., 613.
- (70.) Perkin, Liebig's Annalen, CXLVII., 230.
- (71.) Baeyer, Ber. d. chem. Ges., III., 515.
- (72.) Horbaczewski, Ber. d. chem. Ges., XV., 2678.
- (73.) Erlenmeyer and Lipp, Ber. d. chem. Ges., XV., 1006 and 1544.
- (74.) Arthur Michael, Am. Chem. J., V., 171.
- (75.) von Pechmann, Ber. d. chem. Ges., XVII., 929.
- (76.) Ladenburg and Roth, Ber. d. chem. Ges., XVII., 514.
- (77.) Merck, Ber. d. chem. Ges., XVIII., 2264.
- (78.) Dr. Armstrong.

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LIFE AND WRITINGS

OF

ELISHA NORTH, M. D.,

BY HIS GRANDSON,

H. CARRINGTON BOLTON, Ph. D.

Read before the New London County Medical Association, April 7, 1887.

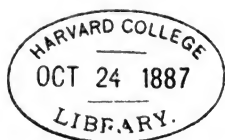
"In Connecticut medical science has been cultivated with great diligence and the happiest results."

JAMES THACHER, M. D.

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The Anchor

MEMOIR OF DR. ELISHA NORTH.

BY H. CARRINGTON BOLTON, PH.D.

[Read before the New London County Medical Society, April 7, 1887.]

Elisha North was born in Goshen, Conn., January 8, 1771, of Connecticut ancestry. He was a lineal descendant of John North (born 1615) who is believed to be the progenitor of all bearing the family name in the United States. John left England at the age of twenty, sailing in the "Susan and Ellen," and landing in Boston, he soon made his way with other emigrants to Hartford, where he did not linger, but settled in the beautiful valley of Farmington. This was in 1635. He purchased a house and lot on the main street of the village, and five years later married; six sons and three daughters were born to him between 1641 and 1659. In 1653 land was entered to him in Farmington, and when the unoccupied lands in the ancient town were divided according to their lists, John, with his two elder sons, John and Samuel, were among the eighty-four proprietors. He was "made free before the court" at Hartford, on May 21, 1657 (Trumbull's Public Records of the Colony of Connecticut, Hartford, 1850, p. 297). He died in 1691, aged seventy-six.

John North's fourth son, Thomas (born 1649), was one of the pioneers in the settlement of Northington (now Avon), Conn. He was a soldier in the Indian wars, and had a soldier's grant of land. In 1708 (?) he married Hannah Newell, and they had five sons and five daughters; his sixth child, Joseph (born 1693), moved from Northington to Goshen, Litchfield County, where he continued to follow the business of his ancestors — farming. Joseph married at the age of forty-one widow Martha Smith (being her third hus-

band), and they had five children. The eldest, Joseph Jr., born 1736, was the father of the subject of this sketch. Joseph, Jr., developed a talent for surgery and medicine, and though he had no regular medical education, he acquired a considerable medical practice. An old chronicle says: "He borrowed books and got ideas from Dr. Meigs," and considering the fact that there was no medical school in the United States in his youth,* this was the best substitute for systematic instruction which could be secured. In 1770 Joseph, Jr. married Lucy Cowles of Farmington, and they had nine children. It is interesting to note that the three eldest sons, Elisha, Joseph, and Ethel, inherited the tastes of this self-made physician, and followed their father's profession. Elisha, the eldest, was born in Goshen January 8, 1771; he entered upon the labors and responsibilities of an active medical man at the age of sixteen, when he took charge of a broken limb, which he succeeded in setting and healing without assistance. He studied with his father, accompanying him in his long drives over the bleak hills of Litchfield County, and gained a practical experience which afterwards served him well. But he felt the need of more systematic training and larger insight into the art of the physician, and made his way to Hartford to pursue studies under the celebrated Dr. Lemuel Hopkins (born 1750, practiced in Hartford from 1784 until his death in 1801). Returning to his native place he practiced until he had accumulated the necessary means to defray his expenses in another and more extended search for higher instruction; at that time his choice of medical schools in the United States was limited to three, the medical college of the University of Pennsylvania, Philadelphia, founded in 1765; the medical school of Columbia College, New York, founded in 1768; and the medical department of Harvard College, founded in 1782. Exactly what determined him to prefer the Philadelphia school we do not know, unless by reason of its being the longest established, and on account of the celebrity of its teachers. The schools at Cambridge and New York city were much nearer, but he made the then considerable journey to Philadelphia. He matriculated at the University in the fall of 1793, and pursued his studies under the dis-

*The first Medical College in the United States was established in Philadelphia in 1765, when Joseph was twenty-nine years of age. This college first conferred the degree of M.D. in 1771.

tinguished Dr. Benjamin Rush and his able colleagues.* He did not remain long enough to obtain a diploma; indeed, but a small part of those who studied at the medical schools in the last century secured diplomas; in the first fifteen years of the Medical School of Philadelphia, the number of graduates averaged about five and one-half a year, while as many as seventy students were in attendance at one time. In the latter half of the eighteenth century attendance at a medical school was resorted to but by few of those who took upon themselves the responsibilities of practitioners of medicine, and Dr. North's enterprise is an indication of the earnestness of purpose which characterized him throughout life.

Meanwhile, the physicians of Connecticut had succeeded in obtaining a charter for a State Medical Association; this was in October, 1792, at Middletown. At the adjourned meeting of the convention held May 15, 1793, at Hartford, Elisha North was admitted to membership in the society. He was at this time only twenty-two years old, yet was regarded as worthy of honor.

On leaving the Philadelphia Medical College, he resumed his practice in Goshen, and immediately took a high rank in his profession. Zealous and indefatigable as a student, he was foremost to adopt improvements in medicine; not blindly, but after careful trial of their value; he endeavored not merely to keep up with the current thought and novel usages but to contribute to the art reforms and inventions of his own busy brain.

Soon after settling in Goshen, at the age of twenty-five, he married Hannah (December 22, 1797), the daughter of ~~Frederick~~ *Fisk* Beach, his fellow townsman, of an ancient and honorable Connecticut family. Of his happiness in domestic life we shall speak at a later period. We may anticipate, however, to remark that his wife was a true helpmeet in the highest degree.

Always eager to seize upon novelties in the healing art which

* In 1793 the Faculty of the Medical School of the University was constituted as follows:

Surgery and Anatomy, ...	Dr. William Shippen, Jr.
Surgery and Anatomy, ...	Dr. Casper Wistar (adjunct).
Practice of Physic, ...	Dr. Adam Kuhn.
Institutes and Clinical Medicine, .	Dr. Benjamin Rush.
Chemistry, ...	Dr. James Woodhouse.
Materia Medica, ...	Dr. Samuel P. Griffiths.
Botany and Natural History, . .	Dr. Benjamin S. Barton.

Early History of Medicine in Philadelphia, by George W. Norris, M.D. Philadelphia, 1886. 4to. Privately distributed.

promised to benefit the human race Dr. North hailed with delight the announcement by Dr. Jenner of the results of his experiments in vaccination. Dr. Jenner's work: "Enquiry into the Causes and Effects of the Variolæ Vaccinæ," published in 1798, did not meet in England with unqualified acceptance, yet but a few months later the young practitioner of Goshen is found experimenting with the new process in a scientific spirit which challenges our admiration.

One of the first men in America to proclaim his confidence in the statements of Dr. Jenner was Dr. Benjamin Waterhouse, Professor of Medicine in Harvard College. In July, 1800, he procured vaccine matter from England, and boldly tested "the experiment in the persons of four of his own children, the eldest being seven years of age, who thus became the first subjects of vaccination in the United States;"* and being afterwards exposed to small-pox infection in the hospital of Dr. Aspinwall they proved to be unsusceptible of its influence."—(Dr. James Thacher's *Am. Med. Biography*, Boston, 1828.)

In September of the same year, Dr. James Jackson of Boston, returning from London, where he had studied under Dr. Woodville, practiced vaccination in Boston and vicinity. Before the close of the year, Elisha North was pursuing his own investigations. He himself describes the first steps as follows:

"A few weeks only before vaccination was begun in Goshen, Dr. Waterhouse of Boston, had received vaccine matter from England. I took my first vaccine fluid warm and fresh from a person in New Haven, who was visited for such a purpose. The distance was nearly fifty miles. This patient had been vaccinated six or seven days before. There was a complete failure very soon afterwards in the business of vaccination in New Haven. As soon as I arrived home I vaccinated three patients, two of whom were children. The children went through the regular process of vaccination, but the virus failed to infect the adult. Those children were immediately put to the usual test of variolous inoculation. The variolous infection occasioned very small effects which soon disappeared."

* According to Mr. Sidney E. Morse, the first four persons vaccinated in America were a member of the family of Dr. Waterhouse, the Rev. Dr. Jedidiah Morse, Richard C. Morse his son, and Sidney E. Morse, himself. *Life of Jedidiah Morse, D.D.*, by Wm. B. Sprague. New York, 1874, pp. 272-273. It is peculiar that Mr. Morse says Dr. Whitehouse vaccinated "one member of his family"; Dr. Thrasher says: "four of his children"; Dr. North says: "six of his children."

Vaccine was introduced into Philadelphia in the Autumn of 1801. Dr. John Redman Coxe relates experimenting on his son, December 29, 1801, in *Phil. Med. Museum*, (V. 221, 1806).

And then he adds with great candor and modesty:

"I was undoubtedly more indebted to chance than to skill for my good fortune in those experiments; for as was afterwards learned, nothing was known on this side the Atlantic with regard to the proper time for taking vaccine virus."

Some months later he addressed a letter to Dr. Waterhouse, stating the difficulties which had attended vaccination in his vicinity, and the Boston physician replied he had experienced similar perplexity. But a few days later he wrote that he had just received a letter from Dr. Jenner communicating the following golden rule in vaccination: "Take the fluid for vaccination on or before the expiration of the eighth day." Of this rule Dr. North, thirty years later, remarks: "This is now known to every tyro in the medical profession, but none can realize its value but those who have experienced the evils occasioned by the want of such information." And it was with this in remembrance that he attributed his first success to chance rather than skill.

The "business of vaccination" as Dr. North calls it, was extensively carried on in Goshen in the winter of 1800-01, by himself, and by Dr. Jesse Carrington, of whom he candidly says: "He was my rival in business." Dr. Carrington was, however, not so fortunate, and met with a calamity at the outset; he had procured some virus from a traveling person (designated in Dr. North's blunt language as a *kine pock peddler*) with which he vaccinated his wife, and others. After Mrs. Carrington got through with what her husband supposed was the *kine pock*, he persuaded her to have variolous infection put into her arm. The unfortunate and believing wife was easily made to understand the object in view, namely, to convince an incredulous public of the utility of the new practice; but to the great disappointment and chagrin of Dr. Carrington his wife broke out with the genuine small pox, and she had to be removed in accordance with the law to a hospital in Cornwall, ten miles distant. Of this incident, Dr. North says: "This calamity and the two experiments I had previously made, were very beneficial to all within their knowledge."

Both these Goshen physicians made a vast number of experiments, some with genuine vaccine lymph, and some with such as proved to be spurious, and also with variolous infection, but no disaster similar to that related again occurred. By degrees they

acquired knowledge for the discrimination of genuine and spurious matters. During the winter many persons were vaccinated half a dozen times before the desired effect would be produced. A trouble and vexation arose which, says Dr. North, was "much greater than in future will probably ever again occur."

Besides the perplexity occasioned by ignorance, these early investigators had to encounter a host of other vexations occasioned by the prejudices of those around both in and out of the medical profession.

We again quote Dr. North at length:

"In the spring of the year 1801 there was no genuine vaccine matter this side of the Atlantic, except in Goshen, and in the hands of Dr. Waterhouse or others in his vicinity. During the winter of 1800-01 there was a complete failure in the cities of New York and Philadelphia, in obtaining genuine vaccine virus. This circumstance enabled me to introduce the kine pock for the first time into the City of New York. This was done in April, 1801, by the agency of a Mr. Hunt. Mr. Hunt visited New York on his own business while he had the kine pock in his arm, and that, too, in the right stage for taking matter. Mr. Hunt at my request called on Dr. Edward Miller, who vaccinated others from his arm. I vaccinated Mr. Hunt from the arm of a little girl. This girl was vaccinated by virus taken in a fluid state from the hand of a Mr. Ives; the pustule on his hand had been derived directly from the udder of a cow, by milking. Thus the first genuine kine pock that was ever introduced into the City of New York originated from an American source."

So far Dr. North's own words. The writer of this sketch has in his possession the original letter of Dr. Edward Miller thanking Dr. North for sending him vaccine matter; the following is a transcription of the letter:

(Copy.)

NEW YORK, 30th April, 1801.

SIR,—I have received by the favor of Mr. Lyman, the letter and enclosures which you have obligingly transmitted to me. Your opinions and practice in respect to cow-pox seem to have been formed in the most judicious and accurate manner; and I cannot but congratulate the district of country which makes up the sphere of your professional labors, on the discernment and ability you display in the introduction and encouragement of such a means (for it scarcely deserves to be called a disease) of preventing and exterminating one of the most terrific distempers when not mitigated by inoculation that ever afflicted the human race.

The discovery of cow-pox must undoubtedly be considered by all intelligent and reflecting persons as one of the most interesting discoveries which distinguish the present inquisitive and enlightened period.

Our failure in the propagation of cow-pox in this city was solely owing to the spuriousness of the matter employed—a disappointment which seems often to have happened in different parts of Britain till physicians became experimentally well versed in the peculiar appearances of the genuine disease. Such occurrences, however, will probably become less frequent as soon as the community and especially medical persons are thoroughly apprized of the sources of fallacy and of the necessity of giving strict attention to all the circumstances of discrimination. I think your publications very properly adapted to guard against the mistakes incidental to this new practice.

I am greatly obliged to you for the kindness of sending some of the vaccine matter. I shall employ it without delay, and if it should fail to communicate the disease, shall take the liberty of requesting a further supply with a view to another trial.

Wishing you every degree of success in your meritorious exertions to extend the usefulness of this discovery, and to improve the condition of the science of medicine, I request you to accept my assurances of the most perfect respect and esteem.

EDWARD MILLER.

DR. ELISHA NORTH, Goshen, Conn.

Dr. Edward Miller was one of the prominent physicians of New York city, an editor (with Dr. S. L. Mitchell) of the *Medical Repository*, and a man of large practice.

In the above letter Dr. Miller refers to the "failure" in New York city to introduce vaccination. Dr. James Thacher, the biographer, says in this connection:

"Dr. Miller of New York received vaccine matter from Dr. Pearson of London, which failed however to produce the genuine disease, nor was another supply sent on from Boston attended with better success." (*Am. Med. Biogr.*, I, 29.)*

Dr. Thacher says nothing of Dr. North's participation in the matter, probably because the facts had not yet been published at the time he (Dr. Thacher) wrote: In January, 1802, a "Cow-pox Institution" was established in New York city. The circumstances connected with the man Ives are too important to be passed by. Dr. North thus narrates them:

"In May, 1801, a young man by the name of Ives came to consult me as a physician. He said he had chills, headache, and fever; also a swelling under his arm and a sore on his hand; this sore upon examination I found to be the cow-pox pustule. Upon inquiry I became completely satisfied that this pustule was produced from infection derived directly from the udder of a cow, by milking. Being pleased with this discovery

* See also: *Med. Repository*, Vol. IV, pp. 79, 204, and 321 (1801.)

(considering it to be the first of the kind which had been made in America), I prosecuted my inquiries still further. The result of these inquiries amounted to this, that this cow did not get her disease from the human subject nor from the horse. . . . Infection taken from Ives' hand (for I saw him at the right stage for taking infection) produced the genuine disease in others."

In the same year, almost the very month that Dr. North was making these observations, Dr. Edward Miller wrote in the *Medical Repository*:

"We hope our readers in the United States will endeavor to ascertain whether the vaccine disease is to be found among the cows of this country, and if so they will employ infection derived from a domestic, in preference to a foreign source." (*Med. Reposit.*, IV, 322, 1801.)

How Dr. North anticipated this suggestion has been stated.

Nearly forty years after Dr. North had thus established the identity of cow-pox and small-pox, the discovery was claimed for Dr. Ceeley of Aylesbury, England. In an article which appeared in the *Medico-Chirurgical Review*, the following passage occurs:

"What many gentlemen in this country failed to accomplish, we are happy to say has been at length achieved by one of the members of our association, Mr. Ceeley of Aylesbury. He resolved to attempt to ascertain whether he could by inoculation impregnate the cow with human small-pox. Twice he has succeeded in accomplishing this important object after many previous fruitless trials. His experiments were conducted in the presence of five medical men and one veterinary surgeon. He produced five vesicles on the cows, from which source several hundred patients have been vaccinated, who have exhibited all the phenomena of vaccination in the most perfect form and complete degree."

The publication of this caused a contributor to the *New London Advocate and Republican* (February 3, 1841), to take up the cudgels in behalf of "our venerable and respected fellow-citizen, Dr. Elisha North," which he did by republishing the account of Mr. Ives' case just quoted.

I have before me, as I write, a small piece of paper, yellow with age, on which is written in Dr. North's peculiar yet legible hand:

"An extract from a discussion had in the *Cheraw Gazette* (S. C.), and in the *Peoples' Advocate*, New London: 'Dr. Jenner discovered the utility of vaccination, while it must in future be unquestionably admitted that the combined investigations of Drs. North and Ceeley in England have established the identity of the vaccine prophylactic with the small-pox.'"

The old manuscript ends here. Obviously Dr. North had

copied the extract so flattering to his *amour propre*, with a view to preservation.

The great opposition which the introduction of vaccination met at the hands of common people is a familiar topic, yet we believe new light may be thrown upon its extravagant character by quoting a few passages of Dr. North's narrative: He says:

"The excitement or opposition ran so high and was so very unreasonable that to get rid of the convincing evidence . . . I was myself, in particular, actually accused of using on design bad small-pox matter. To silence such slander, I begged as a favor that five of my vaccinated patients would visit with me a small-pox hospital at Winchester, eight miles distant, and there be inoculated with warm variolous infection, and likewise see the small-pox for themselves; for some, among other objections, maintained that the kine pock was a worse malady than the small-pox. This last experiment was actually tried and succeeded, and it was acknowledged to be a fair one."

"Another trouble arose in the progress of this business. After we had succeeded with much labor and expense in establishing the utility of vaccination, too many thought that they could vaccinate themselves after they had learned how from us; and such persons doubtless thought it was perfectly a fair game to defraud their teachers of the pitiful fees which were expected."

Dr. North states that he succeeded in driving the small-pox from the adjoining town of Cornwall, but neither he nor Dr. Carrington "made the business of vaccination profitable notwithstanding their great attention." An interesting advertisement of Dr. North in the *Connecticut Courant* of 1811, will be found in the appendix (D).

Dr. North published his comments on the researches of Dr. Waterhouse as set forth in the latter's pamphlet printed in 1802. Dr. North remarks that he thought it his "duty to exhibit much demonstrative evidence with respect to the utility of vaccination," and contrasts his own method of investigation with that of Dr. Waterhouse to the prejudice of the latter. Dr. North admits (in 1829), the imperfection of physicians' knowledge of the management of vaccination, and makes the pertinent inquiry: "Is it not expedient in the present state of our knowledge to have recourse to the cow for vaccine virus as often as may be practicable?"

A question obviously prophetic of these days when "vaccine farms" are recognized institutions auxiliary to the practice of vaccination.

In the spring of 1896 a malignant disease broke out in Massachusetts, which baffled the physicians, soon became epidemic, and proved a terrible scourge. It was first noticed by Drs. Danielson and Mann of Medfield, Mass., in March. The fever was accompanied by a characteristic maculated eruption which caused it to receive the popular name "Spotted Fever." Dr. Miner called it *typhus syncopalis*. Dr. North called it *typhus petechialis*. This disease ravaged New England at various periods from 1806 till 1816. It first appeared in Connecticut in April 10, 1807, at Winchester, Litchfield County, about eight miles from Dr. North's home. Writing of the disease he says: "A disorder has come among us like a flood of mighty waters bringing along with it all the horrors of a most dreadful plague." The history of typhus and its symptoms, as well as the methods of treatment are well known; for a non-medical man to venture on this ground would be a dangerous experiment, all we desire to do is to show the part which Dr. Elisha North took in checking this malady, and informing the public of his experiences and successes. When the disease broke out in Winchester, sweating and bleeding of patients was resorted to; Dr. North at the very outset came to the conclusion that "Death was not occasioned by violence of fever, inflammation, or putrefaction of the system, but by an unaccountable, sudden, and violent prostration of the energy of the brain and nervous system" (Spotted Fever, p. 99). Accordingly, he adopted a method of treatment opposite to that in vogue, "stimulating to the fullest extent," and using "wine, brandy, opium, camphor, Peruvian bark, serpentaria, oil of peppermint, castor, elixir vitriol, blisters, and sinapisms." In his treatise on spotted fever Dr. North devotes an entire chapter to the "Quantity of stimulants to be used," admitting that in some of the cases reported the quantity given was "enormous." Elsewhere he writes:

"I am decidedly of the opinion this disease requires stimulating remedies; but by this I do not mean that in every case patients must take brandy by quarts, or wine by gallons, for I believe that it requires as much judgment in using stimulants as it does in reducing the system" (Letter to Dr. Elijah Munson.—*Phil. Med. Museum*).

During the winter of 1807-8 Dr. North prescribed for sixty-five patients suffering with this disease, of these he lost but one, the second patient to whom he was called (Spotted Fever, p. 99). In

Winchester when the disease first appeared about one-third died (page 127).

Many physicians adopted the plan of using stimulants, some independently, and others in consequence of the publication of Dr. North. Between 1807 and 1810 spotted fever prevailed to an alarming extent in Hartford, Farmington, Wethersfield, Berlin, Bristol, Burlington, Canton, Simsbury, Torrington, Winchester, New Hartford, and Goshen, and the popular excitement concerning it found utterances in the columns of the newspapers of the day. Mr. Babcock, editor of the *American Mercury* (Hartford), was very emphatic in his complaint of physicians with respect to this plague.

The Reverend Dr. Ebenezer Fitch, President of Williams College, was bereaved of his eldest son, "a promising and hopefully pious youth" on the morning of Commencement Day, 1807. This affliction stimulated Dr. Fitch to publish in the *Berkshire Reporter*, of Pittsfield, a letter with two communications, one from Dr. Elisha North of Goshen, and one from Dr. Elijah Lyman of Torrington, "two very respectable physicians" whom he had addressed with inquiries. This, in the earliest publication of Dr. North on spotted fever, bears the date February 12, 1808. It is reprinted in Dr. North's treatise (pages 97 to 102), and has been quoted above. A year later Dr. North published in the *Philadelphia Medical Museum* another letter addressed to Dr. Elijah Munson, a prominent physician of New Haven. It is worthy of remark that both these publications were in answer to inquiries made by persons addressed and by request, facts bearing testimony to the unobtrusive and rather retiring character of their author.

In the second letter named, dated February 12, 1809, Dr. North calls the disease "Typhus petechialis or the malignant Petechial or Spotted Fever," describes the symptoms and his method of treatment, which is substantially as given. One year later Dr. Timothy Hall of East Hartford read a paper (April 10, 1810) before the Connecticut Medical Society on spotted fever, in which, after detailing his experience, he adopts the views of Dr. North, and says:

"Dr. North's method of practice coincides more with my own ideas of the proper method of treating this disease than anything I have seen written on the subject." (Reprint of the proceedings of the Connecticut Medical Society from 1792 to 1829 inclusive [Hartford, 1884]).

The disease continued to spread and to cause great mortality.

At a meeting of the Councillors of the Massachusetts Medical Society held February 7, 1810, it was

VOTED, That a committee be appointed to collect information respecting the history and treatment of a malignant disease commonly called spotted fever, which is now prevailing in the county of Worcester, and has prevailed, within five years past, in Hartford, Conn., and Providence, R. I., and report at the next meeting of the society or councillors."

The interest of medical men in this epidemic is further shown by frequent contributions to both the secular press and to medical journals.

Dr. Samuel Woodward of Torrington, the Rev. Festus Foster, Dr. Bestor, Dr. Fiske, Dr. Williamson, besides those previously named, took prominent parts in this public discussion. These divers contributions Dr. North collected, and together with his own clinical observations and views, published in a duodecimo volume to which we have already alluded. It bears the date 1811, and was printed in New York by T. and F. Swords, printers to the Faculty of Columbia College (for full title see Appendix). In the preface the author states that he has undertaken "to preserve and bring into one view those things which have already been published," in hopes of aiding the medical fraternity; and he adds: "This work was not written for amusement but for utility; the author had a double purpose to accomplish, not only to exhibit the truth respecting the nature and treatment of this disease, but also to produce evidence of this truth." Accordingly, he appends descriptions of many cases.

Dr. North's writings are characterized by great candor, some might say bluntness; he did not shrink from calling a spade a spade, and some persons evidently felt aggrieved, as the following shows. Thirty-five or forty years after the treatise on spotted fever was published, Dr. North planned a second edition; the well worn copy which he used for the purpose is now in my hands; it bears his MS. notes on many pages, and contains more than sixty slips of paper on which are written the proposed changes and additions for the second edition which never saw the light. On one of these slips, in connection with the preface just quoted, we read: "A bigoted person has told me that this preface was extremely faulty; if it be so my brain is so organized that I cannot perceive it."

We shall not undertake to give an analysis of Dr. North's work,

which, though rare, can be found in certain medical libraries. Another quotation from his unpublished notes may be given, since it shows again his dry and candid expression of opinion. In the chapter eight "Of Submurias Hydrargyri," he speaks strongly against the use of mercury, and dwells on its pernicious effects on the constitution. The second edition, had it been published, would have contained the following addition to this chapter.

"A physician said to me years ago that I ought to be ashamed of what I published in the first edition of this work in regard to mercury. With the permission of persons whose heads may be organized somewhat like that person alluded to, I will now state that during more than forty years practice I have known the organization of so many persons so permanently injured by the abuse of that highly fashionable medicine that I think now, as I did then, that cautions in regard to it are highly proper."

In this chapter he also says: "I have myself treated not less than two hundred patients with this disease (spotted fever); of these I have lost two. I have never given calomel except to three of the whole number" (Spotted Fever, p. 67).

Dr. North's treatise was favorably received by the medical fraternity. The editors of the *Medical Repository* highly approved the work, as did the editors of the *New York Medical Journal*.

The editors of the *American Medical and Philosophical Register* (New York), in reviewing the treatise say :

"This is a very respectable work, and by far the largest that has yet been published on the spotted fever. The author appears to have been very diligent in collecting his materials, has evinced considerable discrimination in the selection, and has put together a body of information which, independent of its present usefulness, well deserves a place as a permanent book of reference. But to the merits of a judicious compiler, Dr. North justly lays claim to the character of an *original observer*, and the facts and observations which he himself has related of this disease, which still prevails in different parts of the Eastern States, are among the most valuable portions of his interesting book." (*American Medical and Philosophical Review*, Vol. II, page 440. See Adv. in *Connecticut Gazette*, Aug. 26, 1812.)

Dr. North had now reached the age of forty-two, and his reputation for skill in surgery and judgment in medical art extended over the whole State of Connecticut. Simple and unostentatious in his manners and habits, he never sought selfishly his own aggrandizement; but his worth was appreciated and caused him to be widely resorted to for surgical practice.

Early in the year 1812 there came to him an invitation to remove to the city of New London, then an important port and a center of the whale fishery. The temptation to exchange the vigorous climate of Litchfield County for the more congenial one of the coast, to exchange the hardships of a country physician's life for the amenities of city practice, as well as the opportunities of more frequent and quicker communication with the outside world, and the advantages which would accrue to his growing family now comprising six members, were some of the weighty reasons which decided him to seek a new home.

He moved with his family to New London, May 8, 1812, and soon secured the esteem of his new circle of acquaintances. A contemporary writer, speaking of his career as a physician in New London, says:

"In the practice of his profession, Dr. North exhibited a remarkable degree of caution, deliberation, and careful reflection. When concerned with the health and comfort, and we may add, the moral welfare of his patients or friends, he exercised a conscientious care and thoughtfulness that preserved him from unsafe enthusiasm or dangerous and extreme views. As a counseling physician he enjoyed the confidence and friendship of his brethren, and was much valued for his philosophical habits of mind in cases of difficulty and uncertainty."

Soon after his settlement in New London, the second war with Great Britain broke out, seriously disturbing the prosperity of the seaboard city. A British fleet controlled the entrance to the Sound, and a petty warfare on the water and on the coast kept the inhabitants on the alert and fearful of disaster. Yet "during the whole war not a man was killed by the enemy in Connecticut, and only *one* in its waters upon the coast." (Miss Caulkins' *History of New London*, p. 634.) During this bloodless war the garrisons of Forts Trumbull and Griswold required the attentions of a medical man and Dr. North was called into this service.*

At the early period of which we write, medical etiquette allowed much greater freedom in advertisements in the local press than the present vigorous usage. In examining an imperfect file of the *Connecticut Gazette*, preserved in the rooms of the New London County Historical Society, we have found several interesting

* Probably in the volunteer service only, for the Adjutant-General of the army informs me under date of March 4, 1887, that "the name Elisha North does not appear on the records of the U. S. A., War of 1812, as a commissioned officer or enlisted man."

advertisements showing their prevalence. These we relegate to the Appendix. In the long advertisement of April, 1819, Dr. North offers his services as a surgeon in certain special cases named, and then followed this endorsement :

" We the subscribers being personal friends and medical brethren, residing in the same town with Dr. North, believe the publication of the above will probably benefit society."

[Signed] THOS. COTT, M. D.,
ARCHIBALD MERCER,
D. T. BRAINARD,
N. S. PERKINS.

When one physician can thus secure the public endorsement of his four rivals, it indicates a state of harmony hardly credible in these degenerate days.

At the first meeting of the New London County Medical Society, held after Dr. North's removal to the city, he was admitted to membership (September 22, 1812) : and he appears to have taken an active part in the work of the society during many years. He served as clerk in 1815, as chairman in 1823 and in 1831. He was frequently elected as delegate to the State Association, and was thrice appointed to read papers before the County Society (1814, 1829, 1834). For the last twelve years of his connection with the society the honor of being "over sixty years" exempted him from dues, in accordance with the rules.

Dr. North had joined the Medical Society of Litchfield County in 1811 (September 24th).

Up to the date of his leaving Goshen, Elisha North, though doubtless styled "Doctor" by his friends and acquaintances, had not received the medical degree. On the title page of his work on spotted fever he does not affix any title to his name. Of his medical education we have written, of his qualifications for a diploma there could be no question, and therefore it is not surprising to find that the State Medical Association, at the meeting held in New Haven, October 20, 1813, voted to confer on him the honorary degree of M.D. Dr. North's name appears in this same year as a member of the Examining Committee of New London County. Between the years 1813 and 1821 he was almost continuously sent as a delegate to the annual meetings of the State society; in 1816 he was appointed on the committee to recom-

ment suitable candidates for a degree of M.D. He apparently held no other office in the State society.

Dr. North's reputation as a successful practitioner rests on his skill as a surgeon as well as in the art of healing. In New London he paid especial attention to diseases of the eye and met with great success, exhibiting good judgment, courage, and delicacy of operation. Writing of himself he says:

"I have had the pleasure to prevent total blindness and restore sight to twelve or thirteen persons during the last three years. These would now probably be moping about in total darkness and be a burden to society and to themselves, had it not been for my individual exertions." (See advertisement in Appendix.)

His success as an oculist led him in the spring of 1817 to open an eye infirmary in New London, which was without question the first institution exclusively devoted to eye surgery in the United States. Of this he writes:

"We had attended to eye patients before that time, but it occurred to us then, that we might multiply our number of cases of that description, and thereby increase our knowledge, by advertising the public in regard to an eye institution. This was done; and we succeeded, although not to our wishes in a pecuniary view of the case. Our success or exertions probably hastened in this country the establishment of larger and better eye infirmaries." (*Science of Life*, pp. 88-90.)

Dr. North's allusion to his ill success pecuniarily reminds us of another passage in which he writes:

"Judging from the lowness of medical fees in Connecticut, one would suppose that property regarded as a means of health, was held by the community in higher estimation than health itself."

We may here mention that his skill in delicate operations was perhaps augmented by his lefthandedness, which was marked and persistent. The lack of discrimination in treatment of ophthalmia at this period is illustrated by an anecdote related at the expense of one of his contemporaries. A man came to Dr. North's infirmary suffering with an inflamed eye; after careful examination the Doctor removed some foreign substance like a bit of charcoal, which had caused the irritation, and prescribing a soothing lotion dismissed him. But before the man left the Doctor casually inquired "what have you been doing for your eye?" The man said he had been to Dr. Blank. "Ah!" said Dr. North, "and

what did he do for you?" "He gave me," said the unfortunate man, "thirteen doses of calomel!"

Few persons are now living who were contemporary with Dr. North; many of those still surviving testify with sincerity to his skill as a surgeon. Proofs of this in individual cases are wanting, but he has left in print descriptions of some of his ingenious improvements in methods of operating. He devised a novel method of performing the operation of lithotomy which need not here be detailed. (See Bibliography in Appendix.) He invented an improved trephine and a speculum oculi, both of which he exhibited at a meeting of the State Medical Association in Hartford, in 1821 (May 9th). He also invented a trocar and a new form of catheter, which latter is publicly endorsed by his contemporaries and fellow citizens, Drs. Coit, Mercer, Brainard, and Perkins. This was in 1829. (*Science of Life*, page 201.)

About the year 1824 Dr. North, convinced of the advantages of life on a farm, purchased a small property in East Lyme and removed there with his family, driving into the city for his medical practice. On this farm he found a deposit of peat and he made many experiments with it as a fuel. One of Dr. North's marked characteristics was his habit of seizing upon neglected phenomena, or novel views, adjusting them to existing circumstances, discussing them in a philosophical manner, and then endeavoring to adapt them to philanthropic uses; in short, he rode his hobbies and sought to induce his friends to make them their own. Accordingly peat became for the time being his hobby; he had it dug, dried, and sent into town for sale, but probably never gained much pecuniary advantage from his illy-appreciated enterprise. The results of his philosophic study he embodied in an article on "Fuel," which was published in the *American Journal of Science*. Prof. Silliman, in a note to this article, says that while he cannot regard Dr. North's views as tenable, "all will agree that he is performing an important service by attempting to excite the attention of his countrymen to this neglected but valuable resource, the more valuable because it is so extensively diffused and so easily accessible."

Those desirous of learning more of Dr. North's claims and hopes for peat as fuel are referred to the original article, which will well repay perusal. (See *Bibliography*). A few years later

he withdrew from the farm and took up his residence in Huntington street, New London.

In 1829 Dr. North published in the *Connecticut Gazette* and in other papers several essays under the title: "The Rights of Anatomists vindicated," and signed *Vesalius*. These letters were instigated by a law passed by the Connecticut Legislature in 1824, relative to the exhumation of bodies for the purpose of dissection, "which law converted the slight offense of trespass into the heinous one of felony," and placed anatomists in a very difficult position. These letters are written in an argumentative, lively style, abounding in historical allusions, and with great freedom in expressing the author's views; who sought to induce statesmen to modify the law, and at the same time to lessen in the public mind the horror excited by the surgeon's experiments. His remarks on the status of the State Medical Society and its relations to Yale College are of especial interest to the historian of medical progress in Connecticut.

In the same year Dr. North published a volume of 200 pages entitled: "Outlines of the Science of Life; which treats physiologically of both Body and Mind." . . . "To which are added *Essays* on other subjects." This work gives an interesting insight into the philosophical mind of its author, and in the subjoined essays furnishes incidentally many items which have been already used in preparing this memoir. Dr. North attempts to show that there is in both animals and plants a "sentient spirit" formed by caloric, either from the blood or from the sap, "that every sort of life is dependent upon such a spirit either in an active or a torpid state; that mind as well as the other functions of life is dependent upon this spirit when it is animal, and that no unknown spirit or immaterial nonentity is needed to account for any of the phenomena of vitality." This somewhat materialistic conception is, however, modified by his admitting the immortality of this sentient spirit. He maintains that this spirit originates directly from the blood, and that it is the halitus of the blood, or its elements. And while he regards animals and man alike in respect to this general animal spirit, yet he does not deny the power of God to "make the human soul immortal agreeably to the Christian's faith and hope" (p. 27). He is conscious of the novelty of his views, and before publishing secured from nine physicians (out of ten who examined his MS.) written certificates

favoring the publication. He prints in the belief that "more good than evil will result" from it, and says "little emolument is expected from it; the writing has increased our power as a practical physician, whether it will benefit readers, time must decide."

His work shows a wide acquaintance with the current English literature on physiology, with a predilection for the writings of Darwin; it abounds in illustrations from experience and the testimony of others; its philosophical spirit cannot be questioned, although in the light of modern discovery his conclusions seem untenable. His style is rather repetitious and amusingly discursive, quotations being often introduced from Pope, his favorite poet. His style is also marked by short pithy sentences, which are epigrammatic, and a quaint humor runs throughout the work. A few quotations may well be made, as the book is decidedly scarce.

He speaks of metaphysicians as "curious men who sit at their ease in elbow chairs, for want of something better to do, contemplating and arranging the movements of their own brains *only* into systems of mental philosophy, without interrogating nature abroad as much as they should do" (p. 68).

Referring to social relations, he writes: "Among mankind, the men in private life pretend to govern the women and children, but both the latter often rule the former, and often to the injury of society" (p. 91).

Speaking of the appetites, he says: "The stomach, like a wife, has more power at home than any other organ in the whole family" (p. 52).

The "Science of Life" is followed by six essays reprinted in part from the originals, which we have noticed elsewhere. The most interesting is a "History of Vaccination as practiced in Goshen, Connecticut," a subject we have fully discussed.

Dr. North was fond of recondite studies, and at times made them hobbies. The visit of Dr. Spurzheim to the United States in 1832 awakened an interest throughout the county in phrenology, and Dr. North did not escape the epidemic. He had read and absorbed, though even before this event, the theories of Gall and Spurzheim, and became quite fascinated with them. He published several essays in the local paper (*Connecticut Gazette*), and a small volume bearing the peculiar title: "Pilgrim's Progress in Phrenology by Uncle Toby." In this work "good instruction is given

in the mode of a pleasant conversation in a mixed company of gentlemen and ladies, or to pilgrims in the science." The scene is laid in the town of "Christian Charity," and the conversation is carried on between "Mr. Judicious Discretion, Mr. Phrenologist, Mr. Jealousy, Miss Talkativeness, and Mr. Objector." He claims that phrenology by no means implies materialism and fatalism, and that it is charitable towards all religions. His system of classifying the mental organs differs somewhat from that of Gall and Spurzheim. His dry humor again appears in his writings; he says:

"Mankind are fond of wonderfulness; it is not, however, always necessary to have a big head to command public attention, as some untenably teach; not that I myself have a small head." (p. 68.)

Although Dr. North read and wrote much on topics not immediately connected with his profession, he never neglected his duty towards his fellowmen when called to their aid. He seemed to find recreation in mental exercise unconnected with his business. When Asiatic cholera raged in New London in 1832, he made himself conspicuous by skillfully resisting the destroyer.

Besides the articles cited, Dr. North contributed to the current medical periodicals a number of essays on a variety of topics. So far as we have been able to discover them, they are catalogued in the accompanying bibliography.

Dr. North was exceedingly happy in his family life; his wife was a woman of much character and had the best influence over him; his eight children grew to manhood and womanhood, exhibiting many of the admirable traits of character inherited from both parents. The very names given to three of his boys shows the peculiar bent of his mind; the eldest was named after Harvey, the illustrious discoverer of the circulation of the blood; two others were named after Erasmus Darwin, and William Heberdean, the distinguished Englishmen of science. Three of his sons had the enterprise to found commercial houses in New Orleans, where by industry and unfailing integrity they speedily secured a competence; one of his sons studied medicine, but preferred private study and teaching to the cares of professional life. Yale graduates of twenty-five classes (1830-1854) remember "Lord North" as the painstaking and successful instructor in elocution in that institution. One of his daughters became the wife of the

eminent martyr to science, Dr. Elisha Mitchell, Geologist of North Carolina, and Professor of Chemistry in the University of that State; one married a prominent clergyman of South Carolina, and another daughter married a successful physician of New York city.

One of his children used to relate an anecdote showing his calmness and mild paternal government; when quite young she swallowed a pin, and, greatly alarmed, approached her stern father with the excited cry "I've swallowed a pin!" Dr. North looked up from his book and quietly said: "Well, does it hurt you?" "No, father," replied the child, "Then don't be so careless again!" And this was the end of the consultation.

Being rather careless about keeping his books, making and collecting bills, his good wife used to supervise this important business for family reasons; but in spite of her care, an examination of his ledger after his decease showed this curious entry:

"Mr. Blank, to doctoring you till you died, \$17.50."

Interesting proof of his ill success in collecting bills has been kindly placed in my possession by a member of the New London County Medical Society, in the shape of an unreceipted bill for \$33.08 against the selectmen of the town of Groton, and dated May 23, 1820.

It is related of him that on one occasion he was called upon to treat the foot of a young girl who was foolishly delicate about exposing her naked foot to the physician's gaze. Perceiving her false modesty, as she hesitated to remove her stocking, he said: "Come, Miss Blank, if your foot is clean, let me see it!" Her scruples vanished.

Dr. North was exceedingly absentminded, and this increased with advancing years; devoted to study he sat reading or writing seemingly oblivious of externals, and not noticing persons entering or leaving the room unless they addressed him, when with native courtesy he gave them his attention. The only infirmity which attacked him in his latter years was deafness, and this naturally increased his concentrativeness. His methodical habits, love of philosophical truth, and his singular absentmindedness are exhibited in an anecdote concerning him. A slight fire having broken out in his house while he was in the street near by, a neighbor called out to him: "Doctor, your house is on fire!" He made no reply

but quietly walked into the house. Seeing him so cool, a bystander asked his neighbor and intimate friend Judge Lyman: "What do you suppose the Doctor is going to do?" "Doubtless," answered the judge, "he will consult Count Rumford's works to ascertain the best means for extinguishing fire!"

Dr. North lived to the good age of seventy-three, his later years being passed in comfort and in complete enjoyment of his activity and usefulness; perfect health rewarded his philosophically temperate habits of life. The last act of his life before he was deprived by paralysis of speech and locomotion, was to visit an interesting and important case of disease, and the last connected sentence which he succeeded in uttering was addressed to the physician who took his place in attending the patient.

A memorandum is in possession of the writer bearing the date of his death, December 29, 1843, giving the following particulars: "Height five feet nine inches, an oval and intellectual head with a periphery of twenty-two and six-sevenths inches, mesial line fifteen and one-fourth inches, temperament nervo-sanguine, age seventy-three."

One who knew him well wrote of him thus:

"Dr. North was distinguished by zeal for his patients and the highest degree of integrity, frankness, and disinterestedness, in his intercourse with them, and his efforts for their benefit. His interest in his profession, as a branch of science and as a means of benefiting society and individuals was strong and earnest, and whenever circumstances required took the precedence of all other subjects, yet his mind being incessantly active, was generally occupied when at leisure from the cares and toils of a physician's life with some favorite subject unconnected with the more practical parts of his profession, in expressing his views upon which, he would exhibit an eloquence and an amount of information often astonishingly beyond the importance of the topic, in the estimation of many. His ever active mind dwelt in a remarkable manner in an unworldly sphere of thought and reflection. He lived the life which we attribute to an ancient philosopher; unsuccessful in accumulating property yet in debt to no one; indifferent to a great extent as to his dress and manners, and to his worldly interests, he was often apparently unconscious of the presence of his fellow beings unless his attention was especially called to them. As might be conjectured from this sketch, his moral views were uncommonly pure and high, and it was impossible to suspect him of craft or duplicity. His manners had the simplicity and modesty of those of a child."

The number of individuals yet living who remember the person

of Dr. North is rapidly growing small; our hope is that this inadequate sketch may increase the number of those who will respect his memory.

APPENDIX.

A. BIBLIOGRAPHY OF THE WRITINGS OF ELISHA NORTH, M.D.

- "Account of the Typhus Fever and its Treatment." *Phil. Med. Museum*; IV, pp. 16-20 (1808). A letter to Dr. John Redman Coxe, editor, dated Goshen, Conn., Jan. 13, 1807.
- "Letter on Spotted Fever," dated February 12, 1808, addressed to the Rev. Dr. Ebenezer Fitch. *Berkshire Reporter*, Pittsfield, 1808. Reprinted in his *Treatise*, pp. 98-102.
- "History of the Typhus Petechialis, or the Malignant Petechial or Spotted Fever, as it appeared in Goshen, Connecticut, during the winter of 1807-'08; with such Remarks as may tend to elucidate its Nature and to establish the best Method of Cure." By Elisha North. *Phil. (The) Med. Museum*, conducted by John Redman Coxe; Philadelphia, 1809. Vol. VI, pp. 280-291. Reprinted in his *Treatise*, pp. 126-138. [A letter dated Goshen, February 12, 1809, addressed to Dr. Elijah Munson, New Haven.]
- "Observations on the Hydrocele Capitis Infantum." *Phil. Med. Museum* (N. S.) I, 59 (1810). [A letter dated Goshen, January 18, 1810, addressed to Dr. John Redman Coxe, the editor.]
- "Observations on Cynanche Trachealis." *Phil. Med. Museum* (N. S.) I, 112 (1810). [A letter dated Goshen, April 20, 1810.]
- "A Treatise on a Malignant Epidemic, commonly called SPOTTED FEVER; interspersed with remarks on the Nature of Fever in General, etc., and an Appendix in which is republished a number of Essays written by different authors on this epidemic, with the addition of Original Notes; containing, also, a few original and selected cases, with clinical remarks." By Elisha North. New York: Printed and sold by T. & J. Swords, Printers to the Faculty of Physic of Columbia College, No. 160 Pearl street, 1811, 12 mo, pp. 250.
- "On Extraction of the Stone." An attempt to demonstrate that the bladder may be opened for the extraction of the stone by a posterior method of operating more conveniently to the surgeon and with much greater safety to the patient than by any other method hitherto discovered. *New England Journal of Medicine and Surgery*, XI, p. 113. Republished in *Phil. J. Med. and Physical Science*, August, 1822.
- "On Fuel." *The American Journal of Science and Arts*. Conducted by Benjamin Silliman. Vol. XI, pp. 66-78. October, 1826.
- "The Rights of Anatomists Vindicated," by Vesalius. Three Essays. No. 1 in the *Canal of Intelligence*, Norwich, January 21, 1829. No. 2

in the *State Palladium*, New London, May 12, 1829. No. 3 in the *New London Gazette*, New London, August 19, 1829.

"Outlines of the Science of Life; which treats physiologically of both Body and Mind; designed only for Philosophers and other candid persons. To which are added Essays on other subjects." By Elisha North, M.D. New York: Collins & Co., 117 Maiden Lane. 1829, xx, 202 pp., 12 mo.

"Five Essays on Phrenology (Anthropology)," in *New London Gazette*. No. 1, January, (?) 1835, signed N—. No. 2, July 1, 1835, signed John Gilpin. No. 3, July 22, 1835, signed N. Nos. 4 and 5 unsigned.

"The Pilgrim's Progress in Phrenology." Part I, abridged. By Uncle Toby. New London. Published by Samuel Green. 1836 78 pp. 8vo. *Title on cover*: "The Manly yet Charitable Physiologist's Progress in Anthropology; or a Short Account of the Art of Making Nice and Useful Demarcations with respect to Organical Differences." It contains a scrap of Part I, the whole of Part III, Essays, five in number, and an Epitome.

Dr. North also edited "Morrison's Tract on the Vitality of the Blood."

B. Copy of a document in possession of the New London County Historical Society.

GROTON, January 8th, 1782.

Wee Whose Names are here Under-Wrighten Desiereth that a Town meeting May be Called as Soon as the Authority of Above S^d town shall think proper for the purport of procuring a Vote of S^d town to carry on the Small pox by Inoculation, as wee are Desierus for Our Selves or Some part of Our Famelies may have that priviledg that our Nabours hath had before us.

Simeon Smith
William Morgan
Samuell Adams
David Adams
Jabez Shaler
Obad^b Bailey
Je^d Leeds.

Nathⁱ Niles
Charles Smith
Edward Packer
Jasper Latham, Jun.
Danⁱ Parker
Solomon Perkins
Jesse Brown
John Woodman jr
James Baley
Joseph Turner.

C. Extract from a letter (date not given) written to the Selectmen of Groton by Eben Ledyard. In possession of the New London County Historical Society:

"Dr. Cooley offered to inoculate every person in Groton with kine-pox at $\frac{1}{4}$ pence, and give his bond to pay all expenses if any one got the small pox afterwards.

"[Signed] EBEN LEDYARD."

D. Copy of advertisement in the *Connecticut Courant*, February 6, 1811:

Vaccination. In justice to Dr. Elisha North, who is acknowledged to be a man of integrity and skill in his profession, and is believed, from his large experience in the kine-pox, to be peculiarly well versed in the practice of vaccination, we, the subscribers have been induced to state that Dr. North was one among the first who made a vigorous attempt to introduce into this State the use of the cow-pox. Ten years have elapsed since his efforts for this purpose were commenced. The cow-pox, like all other new discoveries, met, for a considerable length of time, with the most determined opposition. The time has, however, at length arrived in which almost every one acknowledges its utility. We, as well as Dr. North, highly approve of the generous method adopted by the towns of New London and Hartford to induce the people to avail themselves of this great blessing.

SAMUEL LYMAN,	} <i>Selectmen.</i>
WILLIAM STANLEY, JR.,	
ERASTUS LYMAN,	
ERASTUS GRISWOLD,	

GOSHEN, Jan. 14, 1811.

The subscriber informs the people in the adjacent towns, that he will with pleasure extend his practice of vaccination to any distance within a convenient day's ride from his usual place of residence. As he always prefers to use fresh infection, it becomes necessary to communicate the kine-pox to numbers at the same time. This method of management is also peculiarly calculated to reduce the expense to each individual to a very moderate sum. The subscriber will, with promptness and gratitude, attend, at their own places of abode, to all such classes as may apply to him for the purpose of receiving the cow-pox. As vaccination, from its very nature, can never be an object worthy the attention of every physician, the subscriber contemplates that those of his medical brethren who may not choose to engage in this practice will not consider this attempt to extend its benefits as any infringement on their medical rights and privileges.

[Signed] Elisha North.

GOSHEN, Jan. 30, 1811.

The above advertisement was reprinted entire in the *Connecticut Gazette*, New London, June 14, 1815, with the following addition:

The subscriber thinks proper to inform the public in this vicinity that he is ready to vaccinate in the manner he has formerly been accustomed to do, which is detailed in the above advertisement.

[Signed] E. North.

NEW LONDON, June 6, 1815.

Note by H. C. B. In this same number of the *Connecticut Gazette* are two other advertisements of "Kine Pock": one by Elijah Root of East Haddam, who offers to Vaccinate with "genuine Kine Pock matter less than four years old"; and one by Sylvester Wooster of Lyme.

E. Copy of advertisement in the *Connecticut Gazette*, New London, Wednesday, July 1, 1812:

The subscriber not long since notified the citizens of New London and its neighborhood that he had removed to New London, where he offered himself as a practitioner in physic and surgery, and having lately been informed that it was understood he did not intend to practice midwifery, he now takes this opportunity to inform the public that he will as readily attend on calls of that description as any other; also, that he has been much experienced in that part of his profession for twenty years past.

June 30, 1812.

ELISHA NORTH.

F. Copy of advertisement in the *Connecticut Gazette*, New London, May 5, 1819:

To physicians, clergymen, selectmen, and others, whose duty it is to take the lead in society in cases where sickness is concerned.

The subscriber wishes to be permitted to give information that he has invented a new mode of performing the operation of lithotomy, or cutting for the stone in the bladder, which he is CONFIDENT will greatly lessen the danger arising from that source. He hereby offers his services to any one who may have the misfortune to require a surgeon for that purpose. He also wishes to give information that he has so far improved the instruments used for drawing off the urine in cases of obstruction of that fluid, that in future no person need necessarily die from that CAUSE ALONE. He has also now acquired experimental knowledge in the treatment of permanent strictures of the urethra by the Caustic Bougie (a species of knowledge not often acquired in the country), and hereby offers his services to any one who may be afflicted with that distressing complaint. He can also give correct advice and furnish the most improved trusses for ruptured persons. It may not be unuseful to state that, in the management of diseases of the eye I have had the pleasure to prevent total blindness and restore sight to twelve or thirteen persons during the last three years. These would now probably be moping about in total darkness, and be a burden to society and to themselves, had it not been for my individual exertions. Editors of newspapers in and about this region will probably confer a benefit upon society by giving this one insertion in their papers.

[Signed] ELISHA NORTH.

NEW LONDON, April, 1819.

We, the subscribers, being personal friends and medical brethren residing in the same town with Dr. North, believe the publication of the above will probably benefit society.

[Signed] THOS. COIT, M.D.,
ARCHIBALD MERCER,
D. T. BRAINARD,
N. S. PERKINS.

(18)

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HARVARD
COLLEGE

ABSTRACTS OF PAPERS

READ BEFORE THE

NEW YORK ACADEMY OF SCIENCES

IN 1887-'88.

BY

H. CARRINGTON BOLTON, Ph.D.

CONTENTS:

THE COUNTING-OUT RHYMES OF CHILDREN; A STUDY IN INTERNATIONAL FOLK-LORE.

REMARKS ON EARLY PRACTICE OF VACCINATION BY DR. ELISHA NORTH.

NOTES ON RECENT TRAVEL IN EUROPE.

PRELIMINARY NOTICE OF A NEW STUDY IN FOLK-LORE.

NOTES ON THE ROCK-SALT MINES OF PETITE ANSE, LOUISIANA.

EXTRACTS FROM TRANSACTIONS NEW YORK ACADEMY OF SCIENCES, VOL. VII.

NEW YORK

1888.



The Author

ABSTRACTS OF PAPERS

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Henry

BY

H. CARRINGTON BOLTON.

THE COUNTING-OUT RHYMES OF CHILDREN; A STUDY IN
INTERNATIONAL FOLK-LORE.

(Read October 24th, 1887.)

[Abstract.]

Children playing out-door games, such as "Hide and Seek" and "I Spy," in which one of their number has to take an undesirable part, adopt a method of determining who shall bear the burden, which involves the principle of casting lots, but differs in manner of execution. The process is called in Scotland "chapping out" and "titting out," but in England and America it is commonly known as "counting-out." It is usually conducted as follows: a leader, generally self-appointed, having secured the attention of the boys and girls about to join in the proposed game, arranges them in a row or in a circle around him as fancy may dictate. He then repeats a peculiar doggerel, sometimes with a rapidity which can only be acquired by great familiarity and a dextrous tongue, and pointing with the hand or forefinger to each child in succession, not forgetting himself (or herself), allots to each one word of the mysterious formula:

One-ery, two-ery, ickery, Ann,
Fillicy, fallacy, Nicholas, John,
Queever, quaver, English, knaver,
Stinckelum, stanckelum, Jericho, buck!

This example contains sixteen words; if there is a greater number of children a longer verse is used, but generally the number of words is greater than the number of children, so that the leader begins the round of the group a second time, and mayhap a third time, giving to each child one word of the doggerel. Having completed the verse or sentence, the child on whom the last word falls is said to be "out," and steps aside. In repeating the above doggerel, the accent falls on the first syllable of each polysyllabic word; a very common ending is:

One, two, three,
Out goes she (or he) !

and the last word is generally said with great emphasis, or shouted.

After the child thus "counted-out" has withdrawn, the leader repeats the same doggerel with the same formalities, and, as before, the boy or girl to whom the last word is allotted is "out" and stands aside. The unmeaning doggerel is repeated again and again to a diminishing number of children, and the process of elimination is continued until only two of them remain. The leader then counts-out once more, and the child not set free by the magic word is declared to be "*it*," and must take the objectionable part in the game.

The word "*it*" is always used in this technical sense, denoting the one bearing the disagreeable duty, or perhaps the distinguished part, in a game; no child questions its meaning, nor have we learned of any substitute for this significant monosyllable; it is not safe, however, to assert that there is no equivalent when we consider the innumerable whims of the army of children. The declaration to a child: "You are *it*!" following the process of counting out, seems to carry with it the force of a military order, and is, in many cases, more promptly obeyed than a parent's command.

Children learn these rhymes by sound alone from their playmates a few years older; though accuracy is faithfully attempted, changes are introduced from time to time, and in the course of generations the results would scarcely be recognized by the children of an earlier period. The round game of Scandal, which is said to have furnished amusement to English literary celebrities, illustrates the way in which oral communications are distorted. Since counting-out is the main object in view, the puerile mind is probably satisfied with retaining the rhythm, the rhyme, the number of words, and the general construction, any or all of these features. So far as counting-out is concerned in the simple rhyme :

"One, two, three, four,
 Mary at the cottage door,
 Five, six, seven, eight,
 Eating cherries off a plate ;"

it makes no difference whether we say Jennie for Mary, kitchen for cottage, apples for cherries, and picking for eating ; the general effect is the same.

A very natural corruption is that of : "One is all, two is all, six is all, seven" into "One-erzoll, two-erzoll, zickerzoll, zan" but the conversion of "bobtail vinegar" (with which the second line begins) into "Baptist minister," is a surprise. Yet the history of the English language affords continually examples equally eccentric ; the names of old taverns in England have undergone curious transformation at the hands, or strictly at the mouths, of the common people. The British tar who finds his sea-home christened "*Bellerophon*," is not long in transmuting it into *Billy Ruffian*, a much more comprehensible and satisfactory name to him. "*L'Hirondelle*," became in like manner *Iron Devil*.

The school-boy looks upon these rhymes as merely queer sounds and has "no compunction in making them queerer ; and his genius leads him to tack on other nonsense provided it rhymes." (Ellis.)

The number of these doggerels in use among children is far greater than commonly supposed. The speaker has collected no less than 450 current in England and America ; of these he gave about twenty examples.

He has also succeeded in demonstrating that the custom of counting-out obtains around the world among civilized and semi-civilized races, and by correspondence and personal inquiry he has collected examples in the following languages : Penobscot, Japanese, Hawaii, Maráthi, Romany, Arabic, Turkish, Armenian, Bulgarian, Modern Greek, Swedish, Portuguese, Spanish, Basque, Italian, French, Dutch, Platt-deutsch, German ; and with the English above-named they number over 870.

Having established the wide distribution of the custom of counting-out, the speaker discussed the antiquity and origin *first* of the practice and *second* of the rhymes themselves. He finds the practice to be a survival of sortilege or divination by lot. Sortilege was practised among the ancient heathen nations as well as by the Israelites, and he gave many illustrations of this, especially dwelling on the story of Achan related by Joshua.

The use of the lot at first received divine sanction, but after this was withheld, the practice fell into the hands of sorcerers, which very name signifies lot-taker. The doggerels themselves the speaker regards as a survival of the spoken charms used by

the sorcerers of ancient times in conjunction with their mystic incantations. He gave numerous examples of these charms, such as :

“Huat hanat ista pista sista domiabo damnaustra.” (Cato, 235B.C.)

and: “Irririori, ririori essere, rhuder fere,”

and: Meu, treu, mor, phor,

Teux, za, zor,

Phe, lou, chri,

Ge, ze, on.

(Alexander of Tralles.)

In only one instance had the speaker been able directly to connect a child's counting-out rhyme with a magic spell ; according to Leland the rhyme beginning:

One-ery, two-ery, ickery, Ann,

above given, is a Gypsy magic spell in the Romany language.

Tylor, in his “Primitive Culture,” holds that things which occupy an important place in the life-history of grown men in a savage state, become the playthings of children in a period of civilization ; thus the sling and the bow and arrow, which formed the weapons of mankind in an early stage of its existence, and are still the reliance of savage tribes, have become toys in the hands of all civilized children at the present day. Many games current in Europe and America are known to be sportive imitations of customs which formerly had a significant and serious aspect.

Adopting this theory, the speaker holds that games of chance are in part survivals of the practices of the sorcerer, using this word in its restricted and etymological meaning ; he maintains, further, that the spoken and written charms originally used to enforce priestly power, have become adjuncts to these puerile games, and the basis of the counting-out doggerels under consideration.

The idea that European and American children engaged in “counting-out” for games are repeating in innocent ignorance the practices and language of a sorcerer of a dark age, is perhaps startling, but can be shown to have a high degree of probability. The leader in counting-out performs an incantation, but the children grouped around him are free from that awe and superstitious reverence which characterized the procedure in its earlier state. Many circumstances make this view plausible, and clothe the doggerels with a new and fascinating interest.

Following out this idea, the speaker showed many analogies between ancient customs and present games of children, in the use of the pebble, of the inverted cap, in the design for which

the counting-out is applied, etc. He showed the similarity in all languages of the rhythm, admixture of gibberish with words having meaning, and in the use of numerals, and claimed for these analogies indications of antiquity.

He indicated the modern origin of some of the rhymes current in America; as for example:

One, two, three, four, five, six, seven;
All good children go to Heaven;
All bad children go below
To keep company with Guiteau.

He showed also the geographical sources of some of these doggerels, and the influence of environment on them.

In conclusion he referred briefly to the Anglo-Cymric Score, popularly supposed to be an "Indian" method of counting, but in reality of Welsh origin, as shown by Ellis.

(Read November 21st, 1887.)

DR. H. C. BOLTON exhibited an original letter, dated April 30th, 1801, written by Dr. Edward Miller, of New York, to Dr. Elisha North, of Goshen, Conn., which contained information bearing upon *the early history of vaccination in New York City*. The circumstances under which the letter was written are as follows:

Dr. Elisha North practised vaccination in Goshen during the winter of 1800-01 with marked success. In the spring, a young man by the name of Ives went to consult Dr. North for divers slight ailments and a sore on his hand. This sore Dr. North recognized to be a cow-pox pustule, and, on inquiry, learned that it was produced directly from the udder of a cow while milking. With lymph from this pustule, Dr. North vaccinated an infant successfully, and from the infant vaccinated a Mr. Hunt. This latter going to New York on his private business while the lymph was fresh, went, at Dr. North's request, to call on Dr. Edward Miller, and the New York physician thus obtained fresh vaccine matter. The letter exhibited was one by Dr. Miller thanking Dr. North for his kindness in sending him vaccine matter.

The date of the introduction of vaccine matter into New York City by Dr. Elisha North is March 25th, 1801 (*Medical Reposi-*

tory, 1801), and is two months earlier than the date, May 22d, 1801, at which Dr. Valentine Seaman made his first trial of vaccination. Yet Dr. Seaman is often credited with being the first to practise vaccination in New York City. It is interesting to note that the lymph used by Dr. North was derived from an American source, and not imported from England as had always been the custom. Further details of these circumstances, with the entire letter, will be found in the Transactions of the Conn. Med. Society, Vol. III., p. 135, 1887.

NOTES OF RECENT TRAVEL IN EUROPE.

(Read November 28th, 1887.)

(Abstract.)

Under this title Dr. Bolton spoke of his experiences and observations of a scientific and literary character during the preceding summer. After alluding to the deplorable condition of the stokers on ocean steamers, who work in a temperature varying from 92° to 98° (outside being 67°), the speaker pointed out the literary blunder on a tablet erected in 1882 in Westminster Abbey by the dean and chapter. It reads, to the memory of "J. Lemuel Chester, L. L. D., of Columbia College," instead of LL.D., as every tyro knows it should be. In Oxford he visited Dr. J. A. H. Murray, and the remarkable iron "scriptorium" in which the manuscript of the new English dictionary of the Philological Society is preserved. He also visited the Bodleian Library, and made some study of the portraits of Priestley in the Hope collection, and of Dr. Dee's alchemical manuscripts in the Ashmolean collection. He exhibited a photograph of the statue of Dr. Priestley erected in the University museum.

At Brighton he examined the workings of Volk's Electric Railway, a line first opened in August, 1883, and extended afterwards to one mile in length. Cars seating thirty passengers are run at a speed of eight miles an hour by an electric motor of ten horse power placed beneath the floor. The electricity is generated by a fixed Crossley gas engine of twelve horse power, which drives a Siemens dynamo, the current from which is conducted to the rails by cables under the road. There are two steep gradients (1 in 28, and 1 in 14) but the line is generally level, running along the beach. The expense of operating, after four years' experience, is said to be far less than that of steam or

horse power. Over one million of passengers have been transported without the slightest injury. A similarly constructed railway exists at Ryde, I. W.

Crossing the channel to Jersey, the speaker was struck chiefly by the tides, which rise forty feet, and by the cabbages, which grow on stalks eight to twelve feet high. He spoke of the decreasing population, of the picturesque rocky headlands on the north coast, of the geological features, and of the flora and fauna of the island. Passing to France, he proceeded through Brittany to Bordeaux. At Rennes he observed in the handsome park "*Le Thabor*," near the Archbishopal Palace, a long, wide, and deep excavation, called by the people "*l'Enfer*;" inquiry established the fact that the excavation had been made by priests of the adjoining monastery, condemned to do penance by digging the hole and throwing up the earth. The banks are now surmounted by large and old trees. A case of the earth being modified by man, and not a geological phenomenon.

At Bordeaux, he noticed on the occasion of the National Fête, July 14th, a great consumption, in the evening, of barium and strontium nitrates. On the railway between Bordeaux Dr. Bolton was mistaken by French officials for a German spy, and was closely interrogated by a gendarme, but on showing his passport was suffered to proceed.

He alluded to the resemblance between Vichy and Saratoga, to the new monument to Ampère at Lyons, of which he was a native (born January 22d, 1775), and to some enormous hailstones that fell one hot afternoon in Geneva. This storm was followed next day by an atmosphere so pure that Mt. Blanc was distinctly and uninterruptedly seen from before sunrise until after sunset. At Montreux he examined the working of the *chemin-de-fer funiculaire* ascending to Glion. The line, which has an inclination of 57° , is constructed with a central cogged rail, into which cogged wheels on each car are adjusted. Two cars are so connected by cable that when one is at the top of the incline the other is at the bottom, and the motive power is the weight of water introduced into a reservoir beneath the upper car; the water flows into the reservoir from a stream above; as soon as enough enters to overcome resistance, the car moves slowly downward, shutting off the water automatically, and pulling up the other car with its load. At the bottom of the incline the water is automatically discharged from the reservoir. Railways are now run on this plan in several places in Switzerland. That in question is operated all the year around; the expense is obviously very small.

In the valley of St. Nicholas, on the road to Zermatt, the speaker noticed the method adopted by small farmers to recover

meadow land from the ravages of the glacier torrent. By constructing low stone walls at right angles to the stream and extending a short distance from the banks towards the centre, silt is entrapped so rapidly that the space between the walls in course of time becomes completely filled; a coarse grass springs up, and the ground is redeemed. Specimens of the very fine silt collected by him have been placed in the hands of Dr. A. A. Julien for microscopical study.

At the Rhone glacier Dr. Bolton examined the artificial tunnel excavated in the ice and particularly observed the very beautiful color of the light within the tunnel; the tunnel being serpentine, all the light within passed through a thick roof of ice, and the color within was of a lavender blue, brilliant and trying to the eyes. At Luzerne, the speaker visited the so-called Gletscher-Garten, discovered in 1872-75, with its wonderful glacier mills, the largest measuring 8 m. in width and 9.5 m. in depth.

In Munich, Dr. Bolton had the pleasure of social converse with Professor Charles A. Joy, a former president of the Academy, and always its well wisher. Professor Joy sent messages of remembrance to all his friends in the Academy.

Dr. Bolton alluded to the singularly obstructive rules for obtaining books at the Royal Library, Munich, twenty-four hours' notice being required, and spoke of the superb library building at Stuttgart. In Frankfurt, the "Palmen-Garten" with its magnificent conservatory of palms was commended to botanists. A photograph of the interior of the conservatory was exhibited.

In Holland, the speaker made a visit to the little island of Marken; being in the Zuyder Zee, some miles from the mainland and accessible only by sailboats, the inhabitants have preserved, to a notable extent, ancient costumes and customs; they have intermarried to a very large extent, and the speaker thought the little girls especially looked strikingly similar, as if cousins.

In Brussels, the speaker noticed another electric railway run by a motor operated by accumulators placed beneath the seats.

Referring to London, he spoke of his personal friendship with the descendants of the celebrated divine and chemist, Dr. Joseph Priestley, and exhibited a historic cane now in his possession, which was given to Priestley by Thomas Jefferson, third President of the United States. The cane is a Malacca stick with a plain ebony top and a gold band. He also exhibited a number of letters written by Priestley to Wedgwood between 1780 and 1792, and promised on another occasion to make their contents public.

PRELIMINARY NOTICE OF A NEW STUDY IN FOLK-LORE.

(Read, February 13th, 1888.)

(Abstract.)

Dr. Bolton stated that he had begun to collect and investigate the *Terms Used in Talking to Domestic Animals*.

In controlling the movements of domestic animals by the voice, besides words of ordinary import, man uses a variety of peculiar terms, calls, and inarticulate sounds—not to include whistling—which vary in different localities. In driving yoked cattle and harnessed horses teamsters cry “get up,” “click click” (tongue against teeth), “gee,” “haw,” “whoa,” “whoosh,” “back,” etc., in English-speaking countries; “arre,” “arri,” “jüh,” “gio,” etc., in European countries.

In the United States “gee” directs the animals away from the driver, hence to the right, but, according to Webster’s Dictionary, in England the same term has the opposite effect; because the driver walks on the right hand side of his team. In Virginia, mule drivers gee the animals with the cry “hep-ye-ee-a;” in Norfolk, England, “whoosh-wo;” in France, “hue” and “huhaut;” in Germany “hott” and “hotte;” in some parts of Russia, “haitä” serve the same purpose. To direct animals to the left another series of terms is used, such as: “haw” (U. S.); “who-haw” (Va.); “who-hysh” (Me.); “whoosh” (Suffolk); “har,” also “hü” (Germany); “dia” (France); “vishtä” (Southern Russia).

In calling cattle in the field, a great variety of terms are used, of which the following are examples: “bos, bos” (Conn.); “sake, sake” (Conn.); “coo, coo” (Va.); “sook,” and “sookey,” also “sookow” (Southern U. S.); “koeb, koeb” (Me.); “cusha” (Scotland).

In calling sheep, “konan,” and “konanny” (Ga.); “k’day, k’day” (Conn.). In calling horses “kope” is common in the Southern U. S., and the Creoles of Louisiana cry “see-chuck.” In calling hogs in the field “chee-oo-oo” (Va.), “pig-ooy” (Ill.), “chaw-awg” (Va.), “whoop” (Ga.), are some of the terms current in the localities named.

With the exception of whoa, gee, and haw, and some others, these words are not found in dictionaries, and the speaker proposes to form a vocabulary of them. In the cases of inarticulate sounds, chirps, and clicks, he adopts the notation of Professor A. Melvill Bell, author of “Visible Speech.” Of this system and its application to the case in hand he gave illustrations on the blackboard.

Dr. Bolton gave examples of the terms used in Germany, France, Switzerland, Norway, Russia, Southern India, and among the Eskimo. He pointed out certain common features as well as some singular reversals; sounds used in one country to start and urge horses are used in another country, or even in another part of the same country, to stop them. He further gave quotations from early literature, and referred to the explanations occurring in certain English dictionaries of archaic and provincial words.

In conclusion, he stated that this should be regarded as a preliminary notice made for the purpose of asking assistance of persons interested. He is desirous of collecting words and expressions (oaths excepted) used in addressing domesticated animals in all parts of the United States and in foreign lands.

In particular he seeks information as to:

(1) The terms used to start, hasten, haw, gee, back, and stop horses, oxen, camels, and other animals in harness.

(2) Terms used for calling in the field: cattle, horses, mules, asses, camels, sheep, goats, swine, poultry, and other animals.

(3) Exclamations used in driving from the person domestic animals.

(4) Any expressions and inarticulate sounds used in addressing domestic animals for any purpose whatever (dogs and cats).

(5) References to information in works of travel and general literature will be very welcome.

The speaker suggests that persons willing to collect these data may indicate the value of vowels in English by using the vowel signs of Webster's Unabridged Dictionary, and in cases of difficulty terms may be spelled phonetically. He stated that he would be grateful for contributions, oral or written, and that materials used in a future publication would be credited to the contributors. Correspondence should be addressed to him at the University Club, New York City.

NOTES ON THE ROCK-SALT MINES OF PETITE ANSE,
LOUISIANA.

(Read February 13th, 1888.)

(Abstract.)

The southern coast of Louisiana, west of the Mississippi River, is indented by several bays through which the waters of innumerable bayous pass into the Gulf of Mexico. Near the head of one of these bays, known as Vermilion Bay, there is a nearly

circular island of about 2,500 acres in extent, which rises above the low marshes of the vicinity to the height of 180 feet, forming a notable feature in the monotonous landscape. This is the well-known island of Petite Anse, also called Avery's Island after its present owners, in which occurs a remarkable deposit of rock-salt. Petite Anse is now easily reached by rail, *via* the Southern Pacific Railroad, from New Orleans as far as New Iberia (about 125 miles), and thence, by a branch road, 10 miles long, to the salt mine. Cotton and sugar plantations, uncultivated fields, marshes, corn-fields, and cypress swamps alternate with luxuriant forests of live-oak, gum, hickory, black walnut, cypress, maple, and magnolia. About two-thirds of the island are under cultivation, the most profitable crops being sugar, salt, and Tobasco pepper-sauce. Three ranges of hills can be traced, the surface water from which has cut its way deeply through the alluvial deposits, forming ravines, which, with ponds, forests, and cultivated fields, make the island a picturesque oasis in a desert of marsh and cypress swamps.

The existence of salt on this island has been known for a very long time, as shown by the fragments of pottery, arrow-heads, and basket work found mixed with bones of the mastodon, buffalo, and deer, unearthed in recent excavations. The written history of the deposit begins with 1791, when John Hays found a brine spring while hunting. In the last century, salt was made by boiling down the brine, and between the years 1812 and 1815 the amount produced was large. It then ceased for a time. Later, Judge D. D. Avery became owner of the island, and at the outbreak of the rebellion renewed operations on a large scale; the blockade made the salt exceedingly valuable, so that one time a bag of salt was exchanged for a bale of cotton. On May 4th, 1862, Mr. John Marsh Avery attempted to deepen a brine pit, and struck rock-salt at a depth of 16 to 17 feet below the surface. The Confederate Government then instituted mining by means of pits, and, 400-600 men being constantly employed, the island was a scene of prodigious activity. The Northern troops, however, seized the island April 20th, 1863, and put a stop to the industry. During these eleven months, about 22 million pounds of salt are estimated to have been taken out, the average price being 4½ cents per pound.

The first scientific observer who visited the deposit after these events was Professor Richard Owen in November, 1865 (*Am. J. Sci.*, July, 1866, p. 120). In 1866, Professor Charles A. Goessmann visited the place on behalf of the American Bureau of Mines ("Report of the American Bureau of Mines on the Rock-salt Deposit of Petite Anse," 4to, New York, 1867), and one year later it was examined by Professor E. W. Hilgard of the Geo-

logical Survey (*Am. J. Sci.*, Jan., 1869, and "Mineral Resources of the United States," Albert Williams, Jr., Washington, 1883).

To the reports of these gentlemen we owe some of the particulars of this notice.

The rock-salt lies only fifteen to twenty feet beneath the surface. The surface soil is a dark loam, beneath which occur layers of coarse and fine sand, gravel, and clay, all irregularly stratified and in no definite direction. The salt itself occurs as a massive crystalline rock of a saccharoidal texture, dry, hard, and homogeneous. It is of a white color, except in streaks or bands two to six inches in width, which are quite black. The salt appears to have a uniform character in all parts of the mine, and is remarkable for its purity, especially in its freedom from calcium and magnesium salts. It is also quite free from potassium salts; for traces of Stassfurt salts I made especial search in vain. The following analyses show the great purity of this product:

Analysis by Mr. F. W. Taylor, (Smithsonian Institution) March, 1882.		Analysis by E. W. Hilgard. 1863.	
Sodium chloride,	98.731		99.880
Calcium sulphate,	1.192		0.126
Calcium chloride,	Trace		Trace
Magnesium chloride,	0.013		
Silica,	0.024		100.006
Iron sesquioxide,	0.010		
Water,	0.030		
	100.000		

Other analyses made by Professor Goessmann range from 98.88 to 99.60. It is of interest to compare this with rock-salt from other localities.

	Cheshire.	Stassfurt.	Berchtesgaden.
Sodium chloride,	98.30	94.57	99.85
Potassium chloride,			Trace.
Calcium chloride,			Trace.
Magnesium chloride,	0.05	0.97	0.15
Calcium sulphate,	1.65	0.89	
Insoluble,		3.35	
Water,		.22	
	100.00	100.00	100.00

Partial analyses of the black salt have been made by Mr. McCalla, the resident engineer and chemist, who finds that it yields a white solution and about seven per cent of a white insoluble residue, chiefly gypsum. The black color, therefore, seems to be an optical phenomenon. These black bands form well-marked folds in the salt, the space between the ridges and

above them being filled with coarser granules of salt than the rest. Near these black bands the finest cleavage crystals of transparent purity are found. These bands seem to indicate that at some time the rock-mass has been subjected to lateral pressure, causing ridges.

The geological features of the island and the origin of the salt deposit have been discussed by both Professor Goessmann and Professor Hilgard. The former thinks it is "probably of tertiary age," and says, "many circumstances favor the theory that the deposit is a secondary one—resulting from the evaporation of brine springs, originating from beds of rock-salt in some older geological formation—and not a direct residuum of the sea. This explains the entire absence of intercalations of gypsum and the absence of potassium and magnesium compounds."

Professor Hilgard thinks it should be assigned to the cretaceous, since there is "no phase of the tertiary history of the Gulf of Mexico that seems to admit of" the conditions required, viz.: the long-continued evaporation of some very large body of sea-water. He calls attention to the banded structure of the rock-salt, and remarks that the "Stassfurt salts" belonging to the salt mass have long ago been washed into the general ocean.

We would call the attention of geologists to two facts which may throw light on the questions: the occurrence on the island of bedded sandstone and of lignite. The sandstone is exposed at the bottom of a deep ravine about 1,500 feet from the shaft, the rock is of a light gray color and contains little or no calcite. It is distinctly seen to be in place, and is weathered to a considerable depth beneath the surface. At the base of another ravine, formed by a rivulet cutting through the alluvium, gravel and sand, and at a distance of about 2,000 feet from the shaft, there is an outcrop of lignite. The latter is apparently several feet in width and of good quality for economic purposes. Mr. McCalla reports that it contains fifteen per cent of ash. Both the sandstone and the lignite seem to dip in such a direction (S. E.) as would cause them to run beneath the salt. This view is also confirmed by some of the borings. Indications of fossil plants occur in the brown coal, but at the time of my visit it was unfortunately impracticable to dig deeply into it, and I had to be content with a mere surface specimen.

There are four other islands stretching along the coast in the vicinity, but borings have failed to reveal salt on any of them.

The mine is now worked by a system of chambers and cross-headings. The single shaft has reached a depth of 166 feet (including the sump of 6 feet). The old workings at a depth of 90 feet have been abandoned, owing to the infiltration from above of water carrying with it clay and sand, which rendered

the salt impure. The lower level is at a depth of 160 feet. The extent of the excavation in the upper level is about 8 acres, and the extreme ends of the galleries are 900 feet apart. The excavation on the lower level is much smaller. The method of operating is to run galleries about 6 to 8 feet high, and then to work upward to a height of 40 feet, leaving between the galleries large pillars to support the roof. The boring is done with a kind of auger of a German pattern, imported in deference to the prejudices of the workmen, who are largely Stassfurt miners. The auger is worked by hand and penetrates the salt one inch for every 12 revolutions of the bit. The blasting is done with dynamite, of which 80 to 100 boxes, each containing 100 lbs., are used every month, say on an average 150 lbs. daily.

After blasting down 40 feet, the salt is broken by sledges, placed in small hand-carts, and hoisted on a platform to the surface by steam power. About one hundred men are employed by the company, of whom fifty work below the surface. They work on ten-hours time.

The rock mass is quite dry, but, owing to bad management in the early history of the mine, water from the surface runs into it through seams and openings; to remove this, two pumps, capable of throwing out 100 gallons per minute, are run about ten hours out of the twenty-four. The brine pumped out is allowed to waste.

Ventilation is necessitated by the great quantity of dynamite exploded daily. Air is supplied by a fan 8 feet in diameter, 4 feet wide, driven at about 250 revolutions per minute. This, it is estimated, supplies about 600,000 cubic feet of air per hour.

Pockets of an inflammable gas have been repeatedly struck, and on a recent occasion the issuing gas was lit and burnt for an hour or more. Perhaps this phenomenon is connected with the underlying lignite.

The engines used for running the blower, the fan, reels, breakers, etc., are three in number, and aggregate 250 horsepower.

The salt brought to the surface is crushed between corrugated rollers driven at high speed; one set breaks it into lumps from two to three inches in diameter, and another into lumps one-half inch in diameter and finer. It is then ground into various grades by six buhr-stone mills, each capable of grinding 50 tons in ten hours. The salt is sorted by jigs, revolving reels, and blowers, the fine dust being blown out by a horizontal current of air striking against a column of falling salt.

The salt is sent into market in eight grades: (1) Rock-salt in lumps from 100 to 300 pounds, used by farmers, it being placed under sheds for cattle to lick. (2) Crushed salt that passes

over $\frac{1}{4}$ -inch screens and through $\frac{3}{4}$ -inch screens. (3) "Fish salt," including all which passes through a $\frac{1}{4}$ -inch screen. (4) Coarse ground. (5) Medium ground. (6) Fine ground. (7) For sack and barrel salt the coarser particles of grade 6 are screened out with a wire screen of ten meshes to the inch, and the fine dust is blown out. (8) The fine dust thus blown out divides itself by gravity into an impalpable part (which is thrown away, being a small percentage) and a coarser part, which forms table salt. The salt is shipped to market in sacks and barrels.

For the year ending July, 1887, the product was 44,000 tons. In a busy season, the daily shipments run as high as 300 tons. Formerly the material was transported by water, through a canal expressly maintained for the purpose, into the bay some miles distant; now the railway carries it exclusively.

The amount of salt in sight is very great, and the possible extent of the deposit is enormous. Borings show that about 142 acres of ground are underlaid with salt, the extreme depth of which has not been ascertained, though borings have been sunk 190 feet. Everywhere the character of the salt is the same, and the mine is evidently destined to supply the market for generations to come. At present, the owners of the property have leased the mining privilege for a consideration to the American Salt Company.

[Specimens of sandstone, lignite, and salt were exhibited, the latter in transparent cleavage crystals some of which measured $4 \times 3 \times 2$ inches.]

Dr. Bolton expressed his obligations to Capt. Hascall for hospitality, and to the Messrs. Avery for courtesies during his visit. He also desired to thank Mr. McCalla for kind attentions and valued information.

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THE LUNAR SOCIETY

OR

THE FESTIVE PHILOSOPHERS OF BIRMINGHAM
ONE HUNDRED YEARS AGO

BY

HENRY CARRINGTON BOLTON, Ph.D.

Read before the NEW YORK ACADEMY OF SCIENCES, May 7th, 1888.

AUTHOR'S REPRINT.



The Author

Read at the Founding of the Lunar Society in New York, April 27th, 1888; the Society was organized by the following persons: H. CARRINGTON BOLTON, CHARLES S. BULL, JOHN H. CASWELL, CHARLES F. CHANDLER, CHARLES F. COX, HENRY DUDLEY, OLIVER P. HUBBARD, ALEXIS A. JULIEN, ALBERT R. LEEDS, HENRY MORTON, JOHN S. NEWBERRY, ROSSITER W. RAYMOND, and JOHN K. REES.

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THE LUNAR SOCIETY.

The Lunar Society was an informal club or association of scientific men which flourished in Birmingham for nearly forty years. It was founded about the year 1766, by Matthew Boulton, Dr. Erasmus Darwin, Dr. William Small and their friends; they do not seem to have numbered more than eight or ten at any one time, and they met at each other's houses for dinner every month near the full moon, "in order," says Dr. Priestley, "to have the benefit of its light in returning home." Hence the name Lunar Society. The members were accustomed to sit down to dinner at two o'clock, and did not part until eight, exchanging views with each other on topics relating to literature, science, and arts, each contributing his quota of entertainment and instruction.

Each member was allowed to bring with him a friend, and thus many distinguished guests were present at these philosophical banquets. The society occasionally held "meetings extraordinary," in honor of scientific magnates from abroad.

Among the members of the Lunar Society were the following eminent men of science.

Matthew Boulton, F.R.S. (1728-1809), mechanical engineer and inventor of improvements in the steam-engine. A partner of James Watt.

Dr. Erasmus Darwin, F.R.S. (1731-1802), physician, poet, and naturalist. Author of "The Botanic Garden."

Dr. William Small (1734-1775), an intimate friend of Darwin, Boulton, and Watt. He was an accomplished physician, chemist, and mechanist. He held the professorship of mathematics and natural philosophy in William and Mary College, Virginia, for some years, but returned to England and settled in Birmingham.

Thomas Day (1748-1789), a wealthy, eccentric philanthropist, best known as the author of "Sandford and Merton." A friend of Capt. Keir.

Richard Lovell Edgeworth, F.R.S. (1744-1817), author and

philosopher; he contributed papers to the Royal Society. A friend of Day and Darwin.

Dr. William Withering, F.R.S. (1741-1799), physician, botanist, and chemist. He analyzed the mineral witherite named in his honor.

James Watt, F.R.S. (1736-1819), inventor of improvements in the steam-engine, chemist, and engineer. Partner of Boulton.

Captain James Keir (17..-1814), chemist and author; proprietor of several chemical establishments at West Bromwich near Birmingham. A friend of Darwin and Small.

John Baskerville (1706-1775), inventor of superior type, and publisher of standard works.

Rev. Dr. Joseph Priestley, F.R.S. (1733-1804), the father of pneumatic chemistry, theologian, and philosopher.

William Murdock (1754-1839), mechanical engineer, superintendent of the works of Boulton and Watt. Inventor of the system of lighting by gas, and of many improvements in steam machinery.

Rev. R. A. Johnson, F.R.S., of Kenilworth.

Mr. Samuel Galton, F.R.S., a wealthy man of letters, well skilled in chemistry and natural history.

Mr. Samuel Galton, junior, his son.

Dr. Stoke, a physician of Birmingham.

Among the guests known to have been entertained were the following distinguished men of science and letters:

Josiah Wedgwood, F.R.S. (1730-1795), the well-known potter and inventor of the ware called by his name.

Sir Joseph Banks, F.R.S. (1743-1820), botanist, President of the Royal Society.

Sir William Herschel, F.R.S. (1738-1822), the most distinguished astronomer of the century.

John Smeaton (1724-1792), civil engineer, builder of Eddystone Lighthouse.

Dr. Samuel Parr (1747-1825), eminent English scholar and critic.

The Rev. Hugh Blair, D.D. (1718-1800), author of "Lectures on Rhetoric." Professor in the University of Edinburgh.

Adam Afzelius (1750-1836), Swedish botanist. He visited England in 1789.

Dr. Daniel C. Solander, F.R.S. (1736-1782), Swedish Naturalist and physician, Librarian British Museum.

Jean André de Luc (1727-1817), Swiss natural philosopher and geologist.

Dr. Pieter Camper, F.R.S. (1722-1789), Dutch naturalist and anatomist.

Mr. John Wilkinson, iron-master, brother-in-law to Dr. Priestley.

Mr. William Bewly, a surgeon and apothecary of Norfolk, author of letters on the chemistry of gases. A friend of Dr. Priestley.

Mr. Collins, an American "rebel."

Dr. Henry Moyes, of Edinburgh, lecturer on chemistry, though blind. He emigrated to America in 1785.

Mr. M. Robinson Boulton, son of Matthew.

The Rev. Joseph Barrington, Roman Catholic priest of Oscott, a small hamlet, seven or eight miles from Birmingham. Author of several historical works.

Of the original members, two, Small and Baskerville, died in 1775. Dr. Priestley did not become a member until 1780, and, Murdock being so much younger, must have joined still later. Apparently, the society kept no records of its meetings, and but scanty notices of its proceedings can be gathered from the correspondence of its members.

We have given 1766 as the date of the commencement of these social gatherings, but it is probable that they occurred still earlier, for when James Watt visited Soho in 1768 on his way from London to Glasgow, Dr. Small, Dr. Darwin, and Capt. Keir were invited to meet him at "*l'hôtel de l'amitié sur Handsworth Heath*," as Matthew Boulton styled his hospitable mansion. The Society had not perfected its method of conducting affairs as late as 1776, for in this year Boulton wrote to Watt, who had settled in Birmingham:

"Pray remember that the celebration of the third full moon will be on Saturday, March 3d; Darwin and Keir will both be at Soho. I then propose to submit many motions to the members respecting new laws and regulations, such as will tend to prevent the decline of a Society which, I hope, will be lasting."

Boulton was of a thoroughly social disposition, and the formation of the Lunar Society was a natural outgrowth of his genial character. He took pleasure in gathering about him in his home persons of kindred tastes and pursuits, in order both to enjoy their friendship and to cultivate his nature by intercourse with minds of the highest pattern. He was a favorite alike with children and philosophers, with noble guests and simple workmen of Cornwall. London had not at that period absorbed to so great a degree the active intelligence of England, especially in the higher departments of science, art, and literature. The men of that period, though busy with their professional duties and domestic cares, were not so wholly engrossed in the turmoil of business which makes life a burden for so many in the present age, and found time for relaxation in convivial gatherings. In

Liverpool, Roscoe and Currie were the centres of a social intellectual circle; at Warrington, Aiken, Enfield, and, for a time, Priestley, were the leading spirits of another; at Bristol, Dr. Beddoes and Humphrey Davy of a third; and at Norwich, the Taylors and Martineaus of a fourth. In London, Sir Joseph Banks, Dr. Solander, Sir Charles Blagden, Dr. George Fordyce, Drs. Milner and Maskelyne, Captain Cook, Sir G. Shuckburgh, Lord Mulgrave, John Smeaton, and Jesse Ramsden with Edgworth and others, met once a week at Jack's Coffee House, and afterwards at Young Slaughter's Coffee House for social converse. This assemblage had no distinctive name. Benjamin Franklin was a frequent attendant, and alludes to it in his correspondence. But the most distinguished gatherings of all were those of the Lunar Society at Birmingham.

The Patriarch of the Society was Dr. Erasmus Darwin, at least until he removed to Derby in 1782. "His fame as a doctor, philosopher, and poet was great throughout the Midland Counties. He was extremely speculative in all directions, even in such matters as driving wheel carriages by steam." Being very busy with his medical practice at Lichfield, he was not very regular in his attendance at the dinners of the Society, and excused himself for his absence by such a letter as the following:

APRIL 5TH, 1778.

DEAR BOULTON:—I am sorry the infernal divinities who visit mankind with diseases, and are therefore at perpetual war with doctors, should have prevented my seeing all your great men at Soho to-day. Lord! what inventions, what wit, what rhetoric, metaphysical, mechanical, and pyrotechnical, will be on the wing, bandied like a shuttlecock from one to another of your troup of philosophers! while poor I, I by myself I, imprison'd in a post-chaise, am jogg'l'd, and jostl'd, and bump'd, and bruised along the King's highroad to make war upon a stomach-ache or a fever." . . . [Signed] ERASMUS DARWIN.

The society evidently served the purpose of a scientific exchange, each member contributing at the monthly meeting results of his own observations, and reporting news from without the circle. Before the establishment of weekly journals of science, this exchange was the natural means of intercommunication, just as the Athenians gathered on Mars Hill "to tell or to hear some new thing" in the political world. The society seems further to have been chosen by persons from a distance as a channel for announcing their own discoveries or those of others to scientists who would appreciate and publish them. James Watt wrote to the Irish chemist Kirwan as follows:

BIRMINGHAM, Nov. 14th, 1783.

DEAR SIR:—Your obliging communication of Mr. Scheele's process of making the Prussian acid gave me great pleasure, and, according to your desire, I communicated it to our Lunar Society last Monday, who desire me to return to you their thanks. . . .

JAMES WATT.

When Dr. Priestley dissolved his connection with Lord Shelburne, and removed to Birmingham in 1780, he was warmly welcomed by the members of the Lunar Society as a valuable acquisition. He had corresponded with Boulton, and was already celebrated for his publications and his discoveries in gas chemistry. His discovery of nitric oxide dates from 1772; that of ammonia, hydrochloric acid, and oxygen from 1774; sulphurous acid gas and silicon-tetrafluoride, 1775; and nitrous oxide (laughing gas), 1776. He had published three volumes of his "Experiments and Observations on Air," and was engaged on a fourth. Priestley's love of polemics in metaphysics and theology was reflected in his work in science, and though unassuming and gentle in disposition, his advent infused new vigor into the society, and henceforth gave a chemical turn to the weighty discussions of the feasting philosophers.

In his autobiography, Priestley refers to these meetings in the following language:

"I consider my settlement at Birmingham as the happiest event in my life, being highly favorable to every object I had in view, philosophical or theological. In the former respect, I had the convenience of good workmen of every kind and the society of persons eminent for their knowledge of chemistry, particularly Mr. Watt, Mr. Keir, and Dr. Withering. These, with Mr. Boulton and Dr. Darwin, Mr. Galton, and, afterwards, Mr. Johnson, of Kenilworth, and myself, dined together every month, calling ourselves the Lunar Society, because the time of our meeting was the full moon."

The invitations sent out by the host were not formal, but in the nature of friendly letters, in which hints were given as to the intellectual feast in store. Thus, on January 3d, 1781, Watt wrote to Dr. Darwin: "I beg that you would impress on your memory the idea that you promised to dine with sundry men of learning at my house on Monday next, and that you will realize the idea. For your encouragement there is a new book to cut up, and it is to be determined whether or not heat is a compound of phlogiston and empyreal air, and whether a mirror can reflect the heat of the fire. I give you a friendly warning that you may be found wanting whichever opinion you adopt in the latter question; therefore be cautious. If you are

meek and humble, perhaps you may be told what light is made of, and also how to make it, and the theory proved both by synthesis and analysis."

To this communication, Dr. Darwin sent the following curious and characteristic answer:

BEAU DESERT, January 6th, 1781.

DEAR MR. WATT:—You know there is a perpetual war carried on between the devil and all holy men. Sometimes one prevails in an odd skirmish or so, and sometimes the other. Now, you must know that this said devil has played me a slippery trick, and, I fear, prevented me from coming to join the holy men at your house, by sending the measles with peripneumony amongst nine beautiful children of Lord Paget's. For I must suppose it is a work of the devil! Surely the Lord could never think of amusing himself by setting nine innocent little animals to cough their hearts up. Pray, ask your learned Society if this partial evil contributes to any public good, if this pain is necessary to establish the subordination or different links in the chain of animation. If one was to be weaker and less perfect than another, must he therefore have pain as a part of his portion? Pray, inquire of your philosophers, and rescue me from Manichæism.

As to material philosophy, I can tell you some secrets in return for yours, viz., that atmospheric air is composed of light, and the earth of water (and aqueous earth). That water is composed of aqueous gas which is displaced from its earth by oil of vitriol. Pray, make my best devoirs to all the Phlos., and pray tell Dr. Priestley that I wish he would try whether a plant insulated in H_2 will spoil air.

E. DARWIN.

When Darwin removed to Derby, he wrote to the Society:

"I am here cut off from the milk of science, which flows in such redundant streams from your learned Lunatics, and which, I can assure you, is a very great regret to me."

In another letter he said:

"I hope philosophy and fire-engines continue to go on well. You heard we sent your Society an air balloon, which was calculated to have fallen in your garden at Soho, but the wicked wind carried it to Sir Edward Littleton's. Pray, give my compliments to your learned Society."

On another occasion, Darwin wrote to Boulton:

"I hope Behemoth has strength in his loins. Belial and Ash-taroth are two other devils of consequence and good names for engines of fire."

Judging by these letters, Darwin was certainly a lively associate.

The meetings of the philosophers at Mr. Galton's must have been among the most delightful. The host was a man of superior intellectual endowments, well skilled in the exact sciences, and a member of the Royal Society and of the Linnæan Society. He was of the Quaker persuasion, and a man of family and opulence. He at first resided at The Five Ways about one mile from Birmingham, but in 1785 moved to Great Barr House, a beautiful estate of Sir Joseph Scott, about seven miles further from town. The house was large and rambling, it had four or five different staircases and halls, and was more like an assemblage of several houses under one roof. It was situated in an amphitheatre of wooded hills, and was bordered by an old-fashioned Dutch garden full of fish ponds. In this comfortable mansion the Lunar Society was most hospitably entertained. Mr. Galton's daughter Mary Anne (afterwards Mrs. Schimmel Penninck) characterizes the members with a graceful pen. Mr. Boulton, whom she calls the Father of Birmingham, "was tall and of a noble appearance; his temperament was sanguine, with that slight mixture of phlegmatic which gives calmness and dignity; his manners were eminently open and cordial; he took the lead in conversations, and with a social heart had a *grandiose* manner like that arising from position, wealth, and habitual command. He went among his people like a monarch bestowing largess. His forehead was magnificent; the organs of comparison, constructiveness, and of individuality were immense. The characteristics of Mr. Watt, his partner, were altogether different. Mr. Boulton was a man to rule society with dignity; Mr. Watt to lead the contemplative life of a deeply introverted and patiently observant philosopher. He was one of the most complete specimens of the melancholic temperament. His head was generally bent forward or leaning on his hand in meditation; his shoulders stooping, and his chest fallen in; his limbs lank and unmuscular, and his complexion sallow. His intellectual development was magnificent. . . . Whilst Mr. Boulton's eye and countenance had something of radiance, Mr. Watt's were calm, as if patiently investigating or quietly contemplating his object. His utterance was slow and unimpassioned, deep and low in tone, with a broad Scotch accent; his manners gentle, modest, unassuming. In a company where he was not known, unless spoken to, he might have tranquilly passed the whole time in pursuing his own meditations. But this could not well happen; for, in point of fact, everybody practically knew the infinite variety of his talents and stores of knowledge. When Mr. Watt entered a room, men of letters, men of science, nay, military men, artists, ladies, even little children thronged around him. I remember a celebrated Swedish artist having been in-

structed by him that rats' whiskers make the most pliant and elastic painting-brush; ladies would appeal to him on the best means of devising grates, curing smoking chimneys, warming their houses, and obtaining fast colors. I can speak from experience of his teaching me how to make a dulcimer and improve a Jew's harp." "Quite different was the aspect of Dr. Withering; he was the personification of that which belongs to a physician and a naturalist; enormous were his organs of proportion and individuality, and great were his powers of active investigation and accurate detail. His features were sharpened by minute and sagacious observation. He was kind, but his great accuracy and caution rendered his manner less open, and it had neither the wide popularity of Mr. Boulton's, nor the attraction of Mr. Watt's true modesty."

Of Dr. Priestley she says: he was "a man of admirable simplicity, gentleness, and kindness of heart, united with great acuteness of intellect. I can never forget the impression produced on me by the serene expression of his countenance. He, indeed, seemed present with God by recollection and with man by cheerfulness." She differed from Dr. Priestley in his religious views, but pays a handsome tribute to his earnestness, candor, and sincerity.

Captain Keir she characterizes as "the wit, the man of the world, the finished gentleman, who gave life and animation to the party."

Dr. Stoke she calls "profoundly scientific and eminently absent," and relates the following incident in which he was concerned. "On one occasion, when the Lunar Meeting, or 'Lunatics,' as our butler called them, were seated at dinner, a blazing fire being in the room, we were astonished by hearing a sudden *hissing* noise, and seeing a large and beautiful, yellow and black snake rushing about the room. My dear mother, who saw it was not venomous, said to me: 'Mary Anne, go and catch that snake,' which, after some trouble, and thinking all the while of little Harry Sandford and Tommy Merton, I succeeded in accomplishing. We were wondering where it could have come from, when Dr. Stoke said that, as he was riding along, he had seen the poor animal frozen on a bank, and put it in his pocket to dissect, but the snake had thawed and escaped from his pocket. The doctor praised me very much for my prowess, and as a reward he made me a present of my prisoner, which I long kept in a glass jar and carefully tended every day; at last, however, I gave him his freedom."

Of the eccentric Dr. Darwin the lady had less agreeable reminiscences. The doctor had been called professionally to see her mother; he arrived in worn-out, muddy "sulky," fitted

up with receptacles for writing and eating, stocked with sweet confections, of which he was fond, and heaped up with books from the floor to the front window. "We all hastened," she says, "to the window to see Dr. Darwin, of whom we had heard so much, and whom I was prepared to honor and venerate, in no common degree, as the restorer of my mother's health. What then was my astonishment at beholding him, as he slowly got out of the carriage! His figure was vast and massive, his head was almost buried on his shoulders, and he wore a scratch-wig, as it is called, tied up in a little bobtail behind." Meanwhile, amidst all this, the doctor's eye was deeply sagacious, his observation most keen, and his intelligence well calculated to inspire confidence in his patients. When conversation began, his flow of wit and anecdote was most entertaining and astonishing, in spite of an inveterate stammering.

Elsewhere she records the painful impression made on her by the doctor's irreligion.¹

During the years 1780 to 1785, pneumatic chemistry was the principal topic under discussion, for Priestley and Watt were each contributing his share to the much-vexed question of the constitution of water. Cavendish in London, Lavoisier in Paris, and Watt in Birmingham were three rival claimants for the honor of the discovery of the composition of water. Priestley, as a friend of Watt, communicated speedily the results of his experiments, sometimes it is reasonable to believe, over the festive board of the Lunarians, and left the conclusions to be drawn by others. As to the relative merits of the claimants, that is foreign to the purpose of this essay.

The Priestley-Wedgwood correspondence² shows that in 1783 the philosophers were greatly exercised over Priestley's discovery of the conversion of water into air, the fallacy of which he himself afterwards admitted.

The Phlogistic Theory, which had been the controlling spirit in chemical philosophy for nearly a century, received its death-blow at the hands of Priestley himself, when he isolated oxygen

¹ We have ventured to quote, at great length, from Mrs. Schimmel Penninck's graphic reminiscences, because they certainly bear the impress of truth and are lifelike in their portraiture. She had every advantage of forming the acquaintance of the members of the Society, her father being active in it from the time she was eight years old until she was five and twenty, and a tenacious memory, added to a power of discrimination of unusual delicacy, enabled her, in after years, to record her souvenirs. Her mother was a most intimate friend of Mrs. Priestley, and William Priestley was a playmate in her youth. ("Life of Mary Ann Schimmel Penninck," edited by C. C. Hankin. London, 1859.)

² See authorities at the close of this paper.

on the 1st August, 1774. But he, as is well known, failed to perceive the important bearing of his own discovery, and it was across the channel that Lavoisier and other French chemists were skilfully burying the corpse out of sight. The French theory of combustion was but slowly accepted by conservative Englishmen, and slowest of all by the friends of Priestley.

In the transition period, hydrogen was for a time believed to be the elusive phlogiston; to this phase of doctrine, Boulton alludes in a letter to Wedgwood dated March 30th, 1781.

"We have long talked of phlogiston without knowing what we talked about; but now that Dr. Priestley hath brought the matter to light, we can pour that element out of one vessel into another, can tell how much of it by accurate measurement is necessary to reduce a calx to a metal, which is easily done, and without putting that calx into contact with any visible thing. In short, this goddess of levity can be measured and weighed like other matter. For the rest, I refer you to the doctor himself."

A few months later, Priestley himself wrote to his friend, Josiah Wedgwood: "Before my late experiments, phlogiston was indeed almost given up by the Lunar Society, but now it seems to be re-established" (March 21st, 1782).

Again Boulton writes to his partner, Watt, July 3d, 1781.

"I dined yesterday at the Lunar Society (Keir's house); there was Blair, Priestley, Withering, Galton, and an American "rebel," Mr. Collins. Nothing new, except that some of my white spathos iron ore was found to contain more air than any ore Priestley had ever tried, and what is singular, it contains no common air, but is part fixable and part inflammable."

On September 20th, 1785, Watt wrote to Boulton:

"The Lunar Society was held yesterday at Mr. Galton's at Barr. It was rather dull, there having been no philosophical news lately, except Mr. Kirwan's discovery of an air from phosphorus, which takes fire of itself on being mixed with common or dephlogisticated air."

We imagine that the philosophers would have hardly regarded their feast as dull, could Mr. Kirwan have shown to them the beautiful yet nauseating experiment of spontaneously inflammable phosphoretted hydrogen. And a modern Academy of Sciences would be enthusiastic over such a notable discovery.¹

The discussions of the philosophic *convives* were not, however, confined exclusively to chemistry. The period was one of great

¹ Gengembre, one of Lavoisier's pupils, had discovered inflammable phosphoretted hydrogen in 1783, but Kirwan's discovery was made independently.

activity in the world of science; Laplace was applying his mathematical genius to the problems of astronomy; Herschel was sweeping the heavens with his gigantic telescopes; Galvani and Volta were laying the foundations of a revolution in electricity; Count Rumford in Bavaria, was devoting his great energy to industrial and social economy; Hutton and Werner were geologizing in their respective countries; Haüy was systematizing the innumerable crystalline forms occurring in nature; the Mongolfier brothers were experimenting with air-balloons, and prophesying the yet unsolved problem of aerial navigation; Capt. James Cook returned from his memorable voyages around the world full of adventure and novelties in nature; the application of steam to the driving of land carriages and the propelling of boats was gradually being perfected by patience and genius. These together with the metaphysical and even the political questions of the day, must have engrossed the attention of the talented friends who dined together at the full moon. The predilections of their guests sometimes determined the character of the subjects discussed. Thus, in the autumn of 1782, the venerable engineer Smeaton, having business in Birmingham connected with his canal, was invited to attend a meeting of the Lunarians at the house of Watt. Watt wrote of this evening's proceedings to his friend Boulton, then in London, as follows:

"Smeaton grows old and is rather more talkative than he was, but retains in perfection his perspicuity of expression and good sense. He came to the philosophers' meeting at my house on Monday, and we were receiving an account of his experiments on rotatives and some new ones he has made, when unluckily his facts did not agree with Dr. Moyes, the blind philosopher's theories, which made Moyes contradict Smeaton, and brought on a dispute which lost us the information we hoped for, and took away all the pleasure of the meeting, as it lasted two hours without coming half an inch nearer to the point." (October 26th, 1782.)

It has been surmised that the Lunar Society discussed the action of light upon nitrate of silver, and the application of this phenomenon to the production of pictures. This suggestion was made by Mr. W. P. Smith, at a meeting of the Photographic Society of Birmingham in 1863, and was based on the discovery in Mr. Boulton's library at Soho of certain photographic pictures on metallic plates. It was understood at the time that Boulton's rooms had been closed for fifty years, but this proved to be an error, and the pictures were probably made by a Miss Wilkinson who had access to the rooms, and who had experimented in photography soon after its invention by Niepce. It is well known that Thomas Wedgwood, son of Josiah, is said

to have made "silver pictures" under Sir Humphrey Davy's eyes as early as 1791-'93, hence during the existence of the Lunar Society. A fac-simile of one of these early photographs is prefixed to Miss Meteyard's "Life of the Younger Wedgwoods," but she herself throws some doubt on its authenticity.

The philosophical converse of the learned men was sometimes enlivened by humorous interludes, such as the following: Dr. Darwin, whose levity in religious matters was notorious, had invented a speaking machine which pronounced "papa," "mamina," and other words quite accurately. Mr. Boulton, who perhaps had suffered from the caustic wit of the doctor, drew up the following satirical contract.

"I promise to pay to Dr. Darwin, of Lichfield, one thousand pounds upon his delivering to me (within two years from date hereof) an instrument called an organ that is capable of pronouncing the Lord's Prayer, the Creed, and Ten Commandments in the vulgar tongue, and his ceding to me, and me only, the property of the said invention with all the advantages thereunto appertaining."

[Signed]

M. BOULTON.

SOHO, September 3d, 1787.

Witness, JAMES KEIR.

Witness, W. SMALL.

A wide range of topics was admitted in the discussions at the informal meetings. Mrs. Schimmel Penninck, already quoted, gives a vivid picture of an exciting scene in her father's house. It was in the summer of 1788, and Matthew Boulton presented to the company his son M. Robinson Boulton, who had just returned from a long sojourn in Paris. "I well remember," writes Mrs. Schimmel Penninck, "my astonishment at his full dress in the highest adornment of Parisian fashion; but I noticed as a remarkable thing that the company (which consisted of some of the first men in Europe), all with one accord gathered around him and asked innumerable questions, the drift of which I did not fully understand. It was wonderful to me to see Dr. Priestley, Dr. Withering, Mr. Watt, Mr. Boulton himself, and Mr. Keir manifest the most intense interest, each according to his prevailing characteristics, as they almost hung upon his words; and it was impossible to mistake the indications of deep anxiety, hope, fear, curiosity, ardent zeal, or thoughtful gravity which alternately marked their countenances, as well as those of my own parents. My ears caught the words 'Marie Antoinette,' 'Cardinal de Rohan,' 'diamond necklace,' 'famine,' 'discontent among the people,' 'sullen silence instead of shouts of Vive le Roi!' All present seemed to give a fearful attention. Why, I

did not then well know, and in a day or two, these things were almost forgotten by me, but the rest of the party heard, no doubt, in the young man's narrative, the distant though as yet faint rising of the storm which a year later was to burst upon France, and in its course to desolate Europe."

It is proper to note that Mary Anne Galton was but eleven years of age at the time which she describes from memory in her later years.

In 1791 a popular outbreak occurred in Birmingham, which threatened the very existence of the Lunar Society. A riotous mob, led by designing men of the baser sort, took possession, as it were, of the town, and for four days (July 14th to 17th) pilaged and destroyed private property to the value of over one hundred thousand pounds. These July riots have often been described and details of the fanatical and violent proceedings do not belong to this place. We can but briefly say that the animosity was caused by political bias and religious intolerance, and was especially directed against Dr. Priestley and his friends who had openly expressed their sympathy with the French Revolution, and as Dissenters were known to be opposed to the Established Church. The enraged mob, at first small in number, but increasing to more than a thousand, attacked first a company of eighty gentlemen who were dining together at a public house to commemorate the anniversary of the French Revolution. The mob broke the hotel windows, and shouting "*Church and King*," sought out Dr. Priestley, who had not dined with the company. Not finding him, the mob rushed to the "*New Meeting House*," of which the Rev. Doctor was pastor, and destroyed it by fire. They then sought another Dissenting Chapel, and, having levelled it to the ground, marched over a mile to the residence of Dr. Priestley, which was plundered without mercy. His philosophical apparatus was ruthlessly destroyed and his library and manuscripts scattered to the winds. Dr. Priestley and his family barely escaped with their lives and never entered the town again. His cheerful temperament and philosophic habit of mind supported him wonderfully, but he never ceased to lament the loss of valuable manuscripts, in which were recorded the results of twenty years of labor and study.

During three succeeding days the mob continued its work of destruction, almost unchecked by the municipal government. They directed their attacks against the property and persons of Dissenters, and of those holding liberal political views; the houses of the estimable William Hutton, bookseller, of a poor Presbyterian parson Mr. Hobson, and the more costly mansions of Mr. Humphreys and Mr. William Russel, a particular friend

of Dr. Priestley, were pillaged and burned to the ground. The members of the Lunar Society, popularly known as "Lunatics," were the especial object of their hatred and zeal. Shouting: "*No philosophers—church and king forever!*" they attacked Edgbaston Hall, the residence of Dr. Withering, but the timely arrival of the light-horse terminated their wretched work of plunder. Some persons, to escape their fury, wrote: "No philosophers" on the fronts of their houses. Boulton and Watt were not without apprehension of an attack, and placing arms in the hands of their workmen, addressed them on the criminality of the riotous proceedings, and obtained their promise to defend the establishment. But Soho was spared the dreaded attack, owing to the fact, says Watt, that most of the Dissenters lived in another direction.

As a sequel, some of the ringleaders were executed, and the sufferers were awarded partial compensation for their pecuniary losses. Priestley shook the dust of Birmingham off his feet, fled to London, and some three years later emigrated to the wild regions of the Susquehanna in search of peace.

It requires little play of the imagination to conjure up the exciting conditions of the first meeting of the Lunar Society after these frightful disasters. We have found no record or even allusion to this occasion, which called for all the philosophy the learned victims could muster.

Dr. Priestley, while suffering an enforced separation from the society of his fellow-philosophers, was not forgetful of them, and in 1793 he dedicated his treatise, "Experiments on the Generation of Air from Water," to his "valued friends, the members of the Lunar Society at Birmingham." In this dedication, he says: "There are few things I more regret, in consequence of my removal from Birmingham, than the loss of your society. It both encouraged and enlightened me, so that what I did there of a philosophical kind ought in justice to be attributed almost as much to you as to myself. From our cheerful meetings I never absented myself voluntarily, and from my pleasing recollection they will never be absent. Should the cause of our separation make it necessary for me to remove to a still greater distance from you, I shall only think the more, and with the more regret, of our past interviews." "Philosophy," he adds, "engrossed us wholly. Politicians may think there are no objects of any consequence besides those which immediately interest *them*. But objects far superior to any of which they have any idea engaged our attention, and the discussion of them was accompanied with a satisfaction to which they are strangers. Happy would it be for the world if their pursuits were as tranquil, and their projects as innocent and as friendly to the

best interests of mankind as ours." Finally, he concludes by earnestly committing them all, though in religious persuasion differing from himself, "to the protection and blessing of that Great Being whose we are, and whom I trust we all serve, and who established that course of nature which is the object of our common investigation." And then the Rev. Doctor prays "with the greatest esteem and affection" for a happy reunion with them all in another state of being.

On another occasion, Priestley, writing to Watt, again expressed his affection for the members of the society in graceful language. After thanking Watt and Boulton for the gift of a copying machine (invented by the former), the doctor adds: "This and many other things will ever remind me of the obligations I am under to you, and the pleasing intercourse I have had with you and all my friends of the Lunar Society. Such another I can never expect to see. Indeed, London cannot furnish it. I shall always think of you at the usual times of your meeting." (Letter of November 2d, 1791.)

Even after his settlement in Northumberland, the doctor continued to communicate his scientific observations to his friends in the Lunar Society. On December 6th, 1795, writing to his friend the Rev. Theophilus Lindsay, Priestley explains that he forwards through Dr. Young a copy of a paper prepared for the Philosophical Society at Philadelphia, and says: "Please to forward it to Mr. Galton the first convenient opportunity. It contains several new experiments, which must be thought of importance, especially with respect to the new French system with which, though universally adopted, I see more and more reason to be dissatisfied." This paper was entitled: "Experiments and Observations Relating to the Analysis of Atmospheric Air; also Further Experiments Relating to the Generation of Air from Water," and was read to the Society February 5th, 1796.

Still later, we find evidence that the cordial friendship of Priestley with Boulton and Watt seems to have been unbroken, except as distance prevented personal contact. In 1801, the firm sent Priestley a present of a "noble furnace and other apparatus for making large quantities of air," and the doctor, in acknowledging the gift, wrote thus: "I send every good wish to yourselves and all the other members of the Lunar Society, the advantages of which I most feelingly find the want of." (Letter of October 17th, 1801.)

The latest reference to the Lunar Society in Priestley's writings is probably that in the introduction to his essay, entitled: "The Doctrine of Phlogiston Established and that of the Composition of Water Refuted," published at Northumberland in

1803. In this he comments on the almost universal acceptance of the new theory of combustion, and says: "And now that Dr. Crawford is dead, I hardly know of any person, except my friends of the Lunar Society of Birmingham, who adhere to the doctrine of phlogiston."

Dr. Priestley is not the only one who records his attachment to this social organization and to its members individually. In his "Memoirs," Richard Lovell Edgeworth writes: Our Society combined "men of very different characters, but all devoted to literature and science. This mutual intimacy has never been broken but by death, nor have any of the number failed to distinguish themselves in science or literature. Some may think that I ought, with due modesty, to except myself. Mr. Keir, with his knowledge of the world and good sense; Dr. Small, with his benevolence and profound sagacity; Wedgwood,¹ with his increasing industry, experimental variety, and calm investigation; Boulton, with his mobility, quick perception, and bold adventure; Watt, with his strong inventive faculty, undeviating steadiness, and bold resources; Darwin, with his imagination, science, and poetical excellence; and Day, with his unwearied research after truth, his integrity and eloquence—proved altogether such a society as few men have had the good fortune to live with; such an assemblage of friends as fewer still have had the happiness to possess and keep through life."

As the century drew towards its end, the Lunar Society gradually dissolved, its members dropping off one by one. Priestley had emigrated; Thomas Day was killed by a fall from his horse, in 1789; Dr. Withering died of a lingering consumption, in 1799;² Dr. Darwin was carried off by an attack of angina pectoris, in 1802; and the ever-welcome guest Josiah Wedgwood passed away in 1795; Capt. Keir, James Watt, and Boulton, the founder, were almost the only members surviving. The vacant seats remained unfilled and the meetings passed into history. The few lingering survivors found its associations too painful to be continued. But the influence exerted by the society did not die; it had stimulated inquiry and quickened the zeal for knowledge of all who had come within its influence, and this spirit diffused and propagated itself in all directions. Leonard Horner, who visited Soho in 1809, thus refers to the continued moral influence of the association: "The remnant of the Lunar Society," he says, "and the fresh remembrance in others of the remarkable men who composed it, are very interest-

¹ Miss Meteyard, the biographer of Wedgwood, says he was not a member of the Lunar Society, but a guest.

² During his long illness, his friends said: "The flower of physic is withering."

ing. The impression which they made is not yet worn out, but shows itself to the second and third generation, in a spirit of scientific curiosity and free inquiry which even yet makes some stand against Toryism and the love of gain." (Smiles.)

Social gatherings of men having kindred intellectual interests and pursuits have many advantages which are lacking in other organizations of a more formal character. Our migratory American Association has marked social aspects, but it brings together workers in science only once a year, and its chief social advantages result from the acquaintances formed between the entertaining citizens and their scientific guests. Our New York Academy of Sciences, with its noble history, occupies a field of its own, and is the proper place for announcing discoveries in every department of learning, but the parliamentary forms necessary to dignified proceedings forbid or hamper the freest interchange of opinions and the formation of those personal friendships which a social organization like the Lunar Society so admirably fosters.

One of the members of the Lunar Society, Richard Lovell Edgeworth, perceived this difference between the two classes of associations, and states the case in well chosen words. Alluding to the Lunar Society in his "Memoirs," he writes:

"A society of literary men and a literary society may be very different. In the one, men give the results of their serious researches and detail their deliberate thoughts; in the other, the first hints of discoveries, the current observations, and the mutual collision of ideas are of important utility. The knowledge of each member of such a society becomes in time disseminated among the whole body, and a certain *esprit du corps*, uncontaminated with jealousy, in some degree combines the talents of members to forward the views of a single person."¹

¹ In preparing this sketch we have made free use of the following works:

Muirhead's "Life of James Watt," London, 1858.

Muirhead's "Mechanical Inventions of Watt," London, 1854.

Smiles' "Lives of Boulton and Watt," London, 1864.

Krause's "Erasmus Darwin," London, 1879.

Edgeworth's "Memoirs," London, 1820, 2 vols.

Brougham's "Philosophers of the Time of George III.," London, 1855.

Rutt's "Life and Correspondence of Priestley," London, 1832. 2 vols.

Jewett's "Life of William Hutton," London, n. d.

"Life of Mary Ann Schimmel Penninck," by herself, London, 1839.

Meteyard's "Life of Wedgwood," London, 1865. 2 vols.

Meteyard's "Group of Englishmen," London, 1871.

As well as of:—

Forty-one unpublished letters from Priestley to Wedgwood, loaned to the writer by Mrs. Robert A. Wainewright, granddaughter of the great chemist.

It is with such thoughts as these that I have ventured to call together this distinguished company, and to propose the perpetuation of the memory of the historic society of Birmingham by founding in the metropolis of the New World another Lunar Society having similar aims and methods. The original organization has long passed into history; but will not the meetings on this side of the Atlantic be enlightened by the same moon that shone on the festive philosophers of Birmingham ?¹



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